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Study of the Effect of Composite Elements on Bonding Strength of Composite Board

Dissertation Thesis

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………………………..

Podpis

Thanks

This research is done by effort of direct team members and others who help me to handle beside problems. I wish I wouldn’t miss any one but of course I will. I would like to express my sincere appreciation to my dear wife Nigar, for her support and patience; My advisor Mrs. Doc. Ing. Daniela Tesařová, Ph.D for her guidance and advice during my Ph.D study; Mr. Ing. Josef Hlavatý, and Mr. Ing. Stefan Mihailovic who have been a great help in my laboratory studies, Hüsniye Hacıahmet for her assistance in the writing process of my thesis; Mr. Amin Mohammadzadeh and Lec. Seçkin Özcan.

Abstrakt

Práce se zabývá vlastnostmi kompozitního materiálu složeného z plastů a masivních druhů dřev turecké a české provenience. Základní sledovanou vlastností byla pevnost lepeného spoje a faktory, které ovlivňují pevnost lepeného spoje základních komponent kompozitního materiálu.

Současně byly také sledovány vlastnosti základní materiály a vlastnosti kombinací těchto materiálů. Na základě návrhu a výběru zkušebních metod byly v laboratorním výzkumu měřeny vlastnosti jednotlivých komponent a zejména pevnost lepeného spoje. Výběr ověřovaných materiálů vycházel z možnosti jejich aplikace v dřevařském průmyslu. Zkoušené byly masivní druhy dřev ze dvou zemí, a to České republiky a Turecka a zkoušené plasty byly PC, PMMA. Dosažené výsledky a závěry výsledků uvedené v disertační práci mohou být užitečné pro aplikaci v průmyslové výrobě zejména pro toho, kdo řeší problematiku lepšího využití a zpracování základních materiálů při výrobě kompozitních desek nebo výrobě dekorativních materiálů s cílem zvýšení využití dřeva v průmyslu.

Klíčová slova: kompozitní desky, pevnost lepeného spoje, drsnost povrchu Post Hoc Bonferroni Statistický Test.

Abstract

In order to make a composite board in any scope, the main question about quality specification is how we can make it stronger. We studied the elements and parameters included in a composite board such as the materials and combinations of them, or how to combine them. Then we designed a suitable experimental test to measure the bonding strength of the boards. We tried to choose the most applied materials in the wood industry, and sourced them from two countries i.e. Turkey and Czech Republic. The result and Conclusions of this research is useful for who they want to enter in this industry or who are trying to have competitive advantages by searching for a better way of manufacturing the raw materials e.g. composite boards, or the products of decorative and wood appliance industry.

Key Words: Composite Board, Bonding Strength, Surface Roughness, Post Hoc Bonferroni Statistical Test.

CONTENT

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ACRONYMS

ABS -Acrylonitrile butadiene styrene
C^0 -Centigrade degree
HDPE -High-density polyethylene
HIPS -High impact polystyrene
LDPE -Low-density polyethylene
m -Meter
MDF -Medium-density fibreboard
PA -Polyamides
PC -Polycarbonate
PE -Polyethylene
PES -Polyester
PET -Polyethylene Terephthalate
PMMA-Polymethyl methacrylate
PO -Polyolythene
PP -Polypropylene
PS -Polystyrene
PU -Polyurethanes
PUR -Polyurethane
PVC -Polyvinylchloride
PVDC -Polyvinylidene chloride
UV -Ultraviolet
HPL -High-pressure laminate
CPL -Continuous pressure laminate
LPM -low-pressure laminate
HDF -High-Density fibreboard

LDF -Low-Density fibreboard
Mm -Milimeter
TS -Turkish Standarts
TR -Turkey
µm -Micrometer
i.e -These ones
g -Gram
et al -and others
kN -Kilonewton
Cz -Czech
T -Turkey
ISO -International Organization for Standardization
Ra -is the arithmetic of the rougnes profile.
M_0 -Dry weight of wood
V_0 -Dry volume of wood
D_0 -Dry density of wood
D_{12} -Air-dry densty of wood
M_{12} -Air-dry weight of wood
V_{12} -Air-dry volume of wood
σy -Adhesion strength
F max -Maximum force
A -Adhesion surface area
axb -Adhesion surface area

1. INTRODUCTION

Humankind was well settled into the riversides by using woods, though they were engaged in shaping stones at the Old Stone Age. In the Neolithic, the people was started farming, and then having tamed the animals, woods were used to protect and to hedge the animals (Aydın et al, 2007). Therefore, woods and its products have been used well since people had become available in the history.

Woods was the main parts of the *Megaron* style houses and it has become goods with its additional products and the emergence of engraver. It had been known that a framed set of picture depicting the Sun God (as known '*Samas*') with a saw could be known as a sign of where this occupation was started to become available. A pictogram-styled writing emerged in Egypt in B.C.3000 was initially onto the papyrus leaves. After all, woods also became an important item for Turkish people life style in Central Asia such as a tent pole and an arrow to their bows (Aydın et al, 2007).

With the emergence of urbanization and major increases in human population at the middle age, the woods engraving was becoming popular occupation area in which many people was wanted to be a master. After being industrial revolution, the shipping and sea-line was becoming important transportation route, which was mainly resulted in colonize activities. The resultant of changes in politic arena of Europe was cause to the shifts in individual's thinking style. Therefore, Europe was shift up to the era of illumination. At that time, it was seen many advantages both in Science and Arts. Nevertheless, woods being industrial material occurred just after the industrial revolution (Gimpel, 1996).

Specifically, at the middle age, industrialization was resulted in various environmental problems in the Europe. In order fields to be cleaned and farmed, in the needs of timbers which were mainly used in the housing, so many acres of forests were cut and destroyed (Gimpel, 1996). Woods were not only used in heating at houses, but also it has been used in many different areas of life such as building a house, a ship, fences, castles, weaving loom, which was mainly caused into occurring of wooden industry.

The availability of European middle class and renaissance in the Europe, the people life style was shifted from being a naturalist to a modernist that their new life style was supported to emergence of the woodwork and the mass production of house-hold materials. This was also main reason of transition from being an engraver to being a carpenter which was also driven by the developments in the industrial production materials.

The second half 19th century saw the new changes both in human life style and individuals' ideas which was again driven by the fact that there were many developments and innovation in science, arts, technology and politics. In the 20th century, the better life standards and well educated people were also cause to shifting in people life style.

Today, people put more emphasis on esthetic sides of woodwork at their home, so that modular and decorative furniture gained importance. Therefore, furniture and decoration are getting a good partner in the furniture industry. Additionally, solid hard wood has been modified with some petroleum products to make it a stronger, cheap, esthetic and executed material.

In recent years, for coverage of wooden surfaces plastic source of materials such as membrane coating, PVC sidebands are often used. These plastic materials are single shade (blue, claret red, brown etc.) or they have wooden design areas. Wood and plastic have become an integral part. Because of day by day increasing in the furniture industry, learning more knowledge about the materials used in this industry is getting unavoidable.

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural (Americanchemistry.com).

Due to their relatively low cost, ease of manufacturing, versatility, and resistancy to the water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many traditional materials, such as wood, stone, horn and bone, leather, paper, metal, glass, and ceramics, in most of their former uses. In developed countries, about a third of plastic is used in packaging and another third in constructions such as piping or vinyl siding. Other uses include automobiles (up to 20% plastic), furniture, and toys. In developing countries, the ratios may differ - for example, reportedly 42% of India's consumption is used in packaging (Anthony, et all., 2009)

Composition; Most plastics contain organic polymers. The vast majority of these polymers are based on chains of carbon atoms alone or with oxygen, sulfur, or nitrogen as well. The backbone is that part of the chain on the main "path" linking a large number of repeat units together. To customize the properties of a plastic, different molecular groups "hang" from the backbone (usually they are "hung" as part of the monomers before the monomers are linked together to form the polymer chain). The structures of these „side chains“ influence the properties of the polymer. This fine tuning of the repeating unit's molecular structure influences the properties of the polymer.

Most plastics contain other organic or inorganic compounds blended in. The amount of additives ranges from zero percentage (for example in polymers used to wrap foods) to more than 50% for certain electronic applications. The average content of additives is 20% by weight of the polymer. Many of the controversies associated with plastics are associated with the additives (Elias, 2000). Organotin compounds are particularly toxic (Teuten, et al 2009).

Common plastics and uses**:** Polyester (PES); fibers, textiles. Polyethylene terephthalate (PET); Carbonated drinks bottles, peanut butter jars, plastic film, microwavable packaging. Polyethylene (PE); wide range of inexpensive uses including, supermarket bags, plastic bottles. High-density polyethylene (HDPE); detergent bottles, milk jugs, and molded plastic cases. Polyvinyl chloride (PVC); plumbing pipes and guttering, shower curtains, window frames, flooring. Polyvinylidene chloride (PVDC) (Saran); food packaging. Low-density polyethylene (LDPE); outdoor furniture, siding, floor tiles, shower curtains, clamshell packaging. Polypropylene (PP); bottle caps, drinking straws, yogurt containers, appliances, car fenders (bumpers), plastic pressure pipe systems. Polystyrene (PS); Packaging foam/"peanuts", food containers, plastic tableware, disposable cups, plates, cutlery, CD and cassette boxes. High impact polystyrene (HIPS); Refrigerator liners, food packaging, vending cups. Polyamides (PA) (Nylons); Fibers, toothbrush bristles, tubing, fishing line, low strength machine parts: under-the-hood car engine parts or gun frames. Acrylonitrile butadiene styrene (ABS); Electronic equipment cases (e.g., computer monitors, printers, keyboards), drainage pipe. Polyethylene/Acrylonitrile Butadiene Styrene (PE/ABS); a slippery blend of PE and ABS used in low-duty dry bearings. Polycarbonate (PC); Compact discs, eyeglasses, riot shields, security windows, traffic lights, lenses. Polycarbonate/Acrylonitrile Butadiene Styrene (PC/ABS); a blend of PC and ABS that creates a stronger plastic, Used in car interior and exterior parts, and mobile phone bodies. Polyurethanes (PU); cushioning foams, thermal insulation foams, surface coatings, printing rollers (Currently 6th or 7th most commonly used plastic material, for instance the most commonly used plastic in cars). Polymethyl methacrylate (PMMA); contact lenses (of the original "hard" variety), glazing (best known in this form by its various trade names around the world; e.g., Perspex, Oroglas, Plexiglas), aglets, fluorescent light diffusers, rear light covers for vehicles. It forms the basis of artistic and commercial acrylic paints when suspended in water with the use of other agents.

The properties of plastics are defined chiefly by the organic chemistry of the polymer such as hardness, density, and resistance to heat, organic solvents, oxidation, and ionizing radiation. In particular, most plastics will melt upon heating to a few hundred degrees celsius (www.pcn.org). While plastics can be made electrically conductive, with the conductivity of up to 80 ks/cm in stretch-oriented polyacetylene (Heeger, vd 1988) they are still no match for most metals like copper which have conductivities of several hundreds ks/cm.

Using the acrylic and plastic materilas in the furniture sector

High - Gloss Panels: High-glossy products are some modern products which have been developed in World in recent years. They provide deep brightness where they are used. On the other hand, they cause the place to be seen more aesthetic, wide and roomy (http://www.sanorman.com).

The panels made of glossy and semigloss materials are called as the high-gloss panels in our sector. In short, the materials that are called high-gloss are the products such as acrylic, shiny PVC, polyester, poligloss, UV lacquered products. Furniture sector was first introduced panels in high-gloss surfaces in mid-2003. Surface of HİGH-GLOSS materials are UV lacquered over MDF lam and it is 100% brighter. Lacquered surfaces give the opportunity to make paste polish on the minor small scratches. Dimentions:18 mm x 1220 mm x 2440 mm.

High-glossy surfaces are moisture resistant and do not have mould, doesn’t show dirt and is easy to clean. Has a smooth and live surface. The surface is rigid and corrision resistant. Colours look natural and streaks are apparent and don’t contain solvent, plus it is an environment friendly product and resistant to sun light, maintains colour durability, decorative and elegant, Bears a high scratch resistant.

Areas of use: kitchen and cabinet doors, bathroom cabinet doors, bedrooms, teenager group modular articles, shelf systems, decoration works, office furniture (http://www.venni.com.tr). Surface decors of high gloss materials offer us so many alternatives in our desings. The following figures are given as some examples from surface colour of high gloss materials. Some samples are given in Figure 1, Page12.

Figure 1: Non decorative examples from high-gloss materials(http://www.venni.com.tr).

- **Edgebands:** Edgebands are complementary matarials of furniture, which are cut widths from melamine, PVC and etc., materials at certain width. Edgebands industry is varied in recent years as it in the entire furniture accessary sector and new modern products are started to be produced (http://www.sanorman.com). In the beginning the edgebands were produced as melamine iron band, Nowadays, the materials are produced from various materials like PVC (Polyvinyl Chloride), ABS (Acrylonitrile-Butadiene-Styrene), PMMA (Polymethyl Metacrylate) and Aluminum.

ABS (acrylonitrile-butadiene-styrene): is a shockproof, high-quality thermoplastic that can be processed easily on edgebanding machines for covering the edges of carrier materials, mainly chipboards and MDFs. Should is used up to 24 months after the production date (http://www.tece.com.tr). About ABS samples are given in the Figure 2, Page 13.

Figure 2: ABS/PVC edging and high-gloss ABS/PCV edging **(**http://www.tece**.** com.tr).

Laser Edgebands (Polyolythene): “Laser Edgebands” and “Laser Edgebanding Machines” with the latest technology were introduced in *Band Salzuflen*, Germany, at *ZOW 2011 Fair*. Some samples are given in the Figure 3, Page 13.

Figure 3: Laser (Polyolythene) edgebands (http://www.romaplastik.com).

In Laser Edgebands, PE (Polyolythene) based laser-melt adhesive is implemented as laser coat at the back of thermoplastic edgebands. As an alternative, PUR (Polyurethane), which answers to the expectations of kitchen furniture sector, can be used. Laser edgedands are offered with of different colours of edgebands. One of the advantages of Laser Edge Bands is that it can be applied as post-coating process to any thermoplastic Laser edgebads can be produced different from laminated chipboard and MDF (http://www.romaplastik.com).

Dimensions of edgebads: The standard length of 0,40 mm thickness PVC roll is 300 m. The standard length of 0,80 mm thickness PVC roll is 150 m. The standard length of 1 mm thickness PVC roll is 150 m. The standard length of 2 mm thickness PVC roll is 100 m. **Storage;** the recommended storega temperature is between 18 and 25 ^{0}C. The product should be used up to 24 month after the production date.

- ***Finish foil*** is one of the most important parts of panel furniture products. It provides the furniture to be high quality, aesthetic, resistant and economic. Finish foil is easily applied at furniture frames, rounded corners, inclines places and rear sections. Chemical and scratch-resistant foil is produced as matt, semi-matt and bright (http://www.surfaceandpanel.com).
- ***Printed Decor Papers*** are produced with special papers in order to give strength and aesthetic in wood panels. Converted according to the end use of the following products. HPL-High-pressure laminate, CPL-Continuous pressure laminate, LPM-low-pressure laminate, Finish foil and Edgebands). Low-compressed melamine for sub-floor (MDF, HDF, LDF, Plywood and other appropriate surfaces). **Pressing;** Heat: 185-200 °C, time: 35 s., pressure: 25-40 kg/cm^2 and packing: 1270-1870 and 2100 mm width.
- ***PVC membrane and vacuum foils*** are produced by using the latest technology. The materials are used for production of interior and exterior furniture by using membrane and vacuum pressing machines. Due to the thermoplastic speciality, during the pressing period Panel surfaces of 3D door, kitchen cabinet doors and wardrobe look more the appearance of aesthetic. Besides that, these materials are used in profile, baseboard and panels. PVC foil surfaces should not contain a carsinogenic substance according to the health standards that approved by world health organization. It is a decorative surface material which keeps the bacteria away from it. It is stretch-resistant

and applied to sharp edges and channels without any problems. About PVC membrane and vacuum are given in the Figure 4, Page 15.

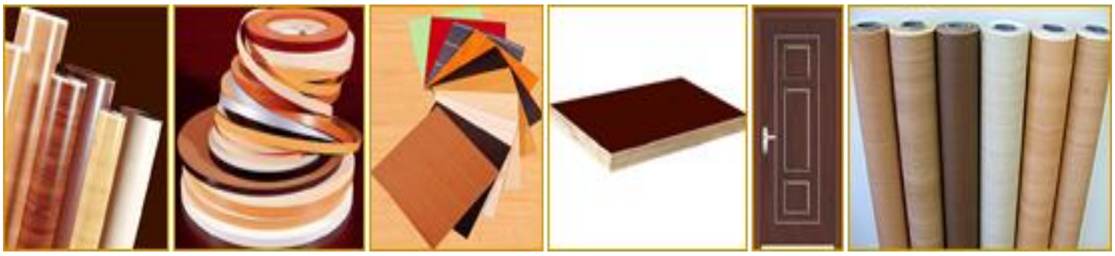


Figure 4: Produced foil examples (http://www.romaplastik.com).

This case has gained further extent and board signs were produced by sticking wood-plastic origin acrylic side by side. Among Acrylic materials, common used ones are Polycarbonat (PC) and Polymetilmetecralat (PMMA). It is known that these sorts of boards are used for decorative purposes. Presence of the factories producing wooden-plastic boards in some countries like Germany, Austria and Czech Republic is known.

This board material's common known name is "Douplex". It is a German rooted word. By sticking 2 millimeters thick, certain wide board coatings stuck in lines on acrylic board surfaces a good combination is offered. Transparent acrylic or sateen acrylic makes up a clear, nice look. Wooden coatings present a visual pleasure by being polished by thin oil making the impression of preserved solid wood. Duplex acrylic boards provide the interaction between 3D harmonical wave structures and wooden acrylic. Combinations of wooden coatings shaped in lines stuck on board surfaces are presented in the Figure 5, Page 15.

Figure 5: Certain thicknes and width wooden board coating acrylic board surface combinations (www.fklisty.cz).

Wooden coatings used to cover raw acrylic board surfaces are processed by oil application and acrylic paint. Acrylic boards might be transparent or in icy design. In

Figure 6, Page 16; acrylic-wooden boards which were produced from different kinds of trees are shown.

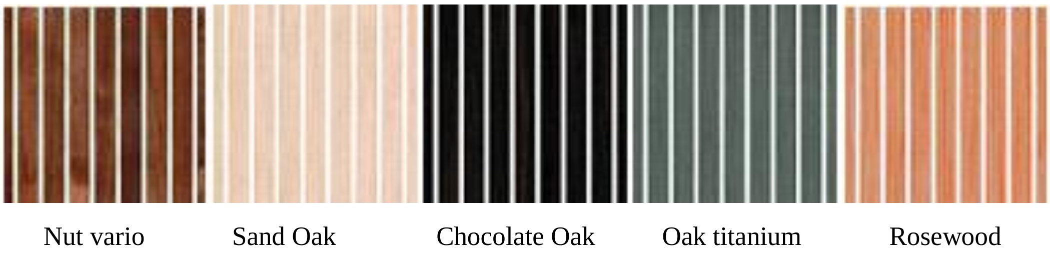


Figure 6: Types of wood: walnut vario, sandy oak, chocolate oak, titanium oak and rose wood (www.fklisty.cz).

Figure 7: Grid design samples (www.fklisty.cz).

Grid designs shown in Figure 7, Page 16; are derived by sticking grid shaped wood on colorful acrylic boards; they are used as decorative materials in furniture design. They might be transparent or colorful acrylic paint. Illumination is possible by putting the lights at the back of the material. Surface of the material may be cleaned easily.

Figure 8: Acrylic-wooden board used as office partitions (www.fklisty.cz).

Acrylic- wooden board size shown in Figure 8, Page 16; 5 or 8 mm thick, 1000 x 2000 mm in size, spaces between wooden coatings are 12 or 18 mm acrylic, 20 mm wide wood + 5 mm wide acrylic are commonly manufactured sizes of acrylic.

Figure 9: Boards designed solid + acrylic materials side by side (www.design-akustik.at).

In Figure 9, Page 17; boards are derived from wooden strips in certain thickness and width, and acrylic strips stuck side by side. Wooden surfaces are protected by polish or wood protectors. Solid strips and acrylic strips should be stuck to each other without any space in a waterproof way. Surface is raw or colorful acrylic material; transparent or icy sheet thickness is 20 mm, 26 mm or 40mm; dimensions are 1000 x 2000 mm, 20 mm wood + special acrylic 5 mm long special acrylic are the most preferred ones. Various acrylic + acrylic board applications are given. In Figure 10, Page 17; in Figures 11 and 12, Page 18.

Figure 10: 3D wavy surface and door acrylic board applications (www.design-akustik.at).

Figure 11: Acrylic-wooden application with filler applied in the frame on a piece of furniture (www.design-akustik.at).

Figure 12: Acrylic-wooden board application on a sales stand a shopping center (www.design-akustik.at).

2. LITERATURE REVIEW

Color, pattern and texture of the wooden material determine the quality of the products, and these characterisrics differentiate it from the other materials. Wood surface has an important role in its usage in different techniques. Thus, recognising or testing the anatomical qualities and characteristics of wood increases the importance of the surface quality in wooden or wood based materials in wood products industry (Malkoçoğlu and Özdemir, 2003).

The success of the surface processes (like puttying, coloring, polishing, lacquering etc) applied to protect, glamorize and increase the economic cost of the furniture in their final status depends on wooden material's surface smoothness (Richter et. al, 1995).

Smoothness is defined as roughneesses on the surface of the wood occuring periodically and in low frequency except the form and flactuation errors as a result of the processes. It is necessary in forest products industry to check the wood quality and surface roughness in order to keep the product quality in appropriate level as it affects the wood bonding and loss during production. Wood surface has an important role in its usages for different processes. Even if the wood surface is rasped or sanded well, it is not smooth because of the cell gaps (Ulusoy, 2011).

Since the roughnesses are formed among the vessels, tracheids, medullary rays, parenchyma, resin canals, and fibers as a result of cutting the cells with different cutters in the process of shaping the wood in machines, the processing systems, such as cutting, peeling and planing (Sulaiman, 2009), further influence the surface roughness. The anatomic structure of the wood, especially the cell cavities, and the nonhomogeneous structure of the wood is influential in the size of these cavities (Strumbo 1963, Peters, and Cumming, 1970). Surface roughness is also influenced by the cross grain annual ring width, rays, knots, reaction wood, ratio of early wood and late wood (Taylor et al. 1999).

After some solid wood materials are rasped, it is aimed to determine surface flatness. Wood samples taken from *Fagus orientalis, darmast oak (Quercus petreae spp.), circussian walnut (Juglans regia L.), cedrus libani, silver lime (Tilia grandifolia Moench.) and African mahogany (Khaya ivorensis A.Chev.) are rasped in wedge angles of* 36°, 38°, 40°, 42° , 44°; in radial and tangent directions with the feed rate of 5 m/min and 9 m/min. In determination of surface roughness, in accordance with the principals of TS 6959, TIME TR- 200 surface roughness testing tool, which can measure the sequential change of the profiles, was used. As a consequence, the best surface is reported as 4.72 µm on cedrus libani with wedge angle 42° in radial direction and 5m/min feed rate 4.72 µm (Duran, 2005).

The samples taken from yellow pine and chestnut wood, which were sheared with 20 and 40 toothed circular saw, on radial direction with the feed rate 5 and 9 meter per minute were exemined. According to this examination, better surfaces have been obtained from yellow pine wood (7.47 µm). Better surfaces were obtained with forty-toothed saw. It is reported that better results (7.75 µm) were taken from the shear with the feed rate 5m/min (Kılıç and Demirci, 2003).

Acacia (robinia pseudecacia) *and* oak (quercus pedinculata) samples which were sanded with oscillating sanders with 40, 60, and 80 grit size were tested. As a result of the testing process, acacia wood (9.54 µm) generated better surfacess than oak wood (10.48 µm). Besides, tangent direction cuts gave better surfaces compared to radial direction cuts. Grit size also made a difference on surface roughness. For example, 80 grit size sand (8.85 µm) gave better surface than 60 grit sized sands (9.47 µm); and 60 grit size produces smoother surfaces than 40 grit sized sands. It is also reported that the smoothest surface obtained from acacia wood sanded with 80 sized sand in the tangent direction (Örs, and Demirci, 2003).

It is reported that on samples from Spruce (Picea abies L.) prepared by sanded in the radial and tangent direction and 45° angle to the fibers, there is not a significant difference in surface roughness values according to their shear directions. On samples taken from spruce (Picea abies L.), black pine (*Larix decidua Mill*.), duglas abies (*Pseudotsuga menziesii Mirb*.) which were rasped firstly then sanded with 120 sized sandpapers, it was seen that there was no significant difference between the spruce and black pine woods but on duglas abies surface roughness value was considerably low (3±0.3). At the end of the sanding process it was found that surface roughness values for black pine was 7.3±0.3 ;for spruce 7.9±0.3 and for duglas abies 8.3±0.4. It is also reported that surface roughness of sanded surfaces has doubled the roughness of rasped surfaces (Schirle, and Richerd, 2002).

Fagus prientalis, oak, yellow pine and abies woods are firstly sheared on the tangential and radial direction with a circular sawing machine. Then, they were rasped on a three knives thickness planer. Finally, they are sanded by 80 sized grit sands. It is reported that the smoothest surface (5.23 μm) was gained from yellow pine wood (Balkız, 2000). Oak and acacia woods sheared with 20, 24 and 50 tooth saws on tangent and radial directions to the annual rings with the rate 5 and 9 m per minute. In this shearing process, it is stated that smoothest surface (7.31 μm) was taken from acacia samples which were sheared on tangential direction with 40-toothed saw (Örs, and Demirci, 2001).

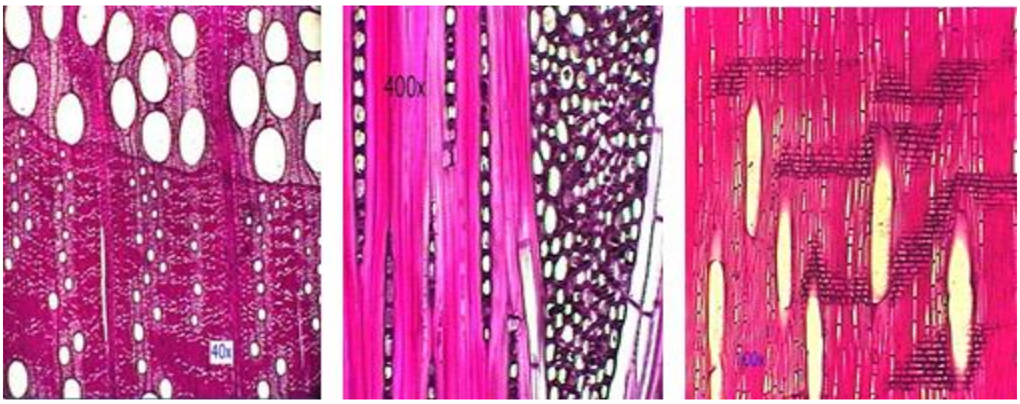
Sanding process has been done with fogus orientalis, yellow pine, oak and acacia woods on tangential and radial directions with two and four blades. As a consequence, 4 blades rasping and tangential shearing gave smoother surface; also there was no difference between the types of blades. The highest surface roughness was reported by oak wood at 7.50 μm (Gürleyen, 1998).

In manufacturing wood based products, surface texture affects product class, quality, surface process convenience, gluing and the subsequent production processes. Smoothness degree differs on the product itself and between various product types (Funck, vd, 1992).

Surface roughness may occur as a result of the production methods used and the other effects. These are minor level surface roughness (TS 6956, 1989). Surface roughness occurs in three different types. First one is able to be seen by bare eye. The second one is just able to be felt and the third one may be on a level that is measured by precision electronic devices (Ilter, et al. 2002).

When it is mixed with homogeneous materials, wood has hallmarks because of its anatomical structure which has an anisotropic structure. Because of this anatomical structure, sawing, shearing and rasping processes are applied but a totally smooth surface can’t be obtained (Aydın, and Çolakoğlu, 2003). Therefore, surface roughness on wooden materials varies, firstly, according to anatomical structure, secondly machines used and surfaces processing methods (Sieminski, and Skarzynska, 1989). During wood’s process with machines, wood cells are cut with knives. Wood units’ gaps such as tracheas, parenchyma, resin canals and fibers come out. These gaps’ sizes are related to the type of tree, the area spring and latewood covers and sections (Aydın and Çolakoğlu**,** 2003).

Durmast oak (Quercus petraea Lieble) has big tracheas with rings, tracheas of spring wood are very big, tangential caliber is about 400 µm, they make up individual or multiple sets. In latewood tracheas are about 30-140 µm. Longitudinal parenchymas are many in number. Their piths are ranged in two different ways. Narrow single files are of the height of 25 cells and the distance between them is variable. Wide and multi-rowed ones are wider than 20 cells and they may be 2 or 3 cm high. Its wood is tough and heavy. In figure 13, Page 22; durmast oak’s microscopic structure is demonstrated (As, et al.**,** 2001).



Cross section Tangential section Radial section

Figure 13: Microscopic structure of Durmast oak *(Quercus petraea Lieble.)* (Bozkurt and Erdin, 2000).

According to the tree's growing conditions, annual ring width and weight density will affect surface roughness. The less the width of the annual ring gets, the better gets the wood surface **(**http://botit.botany.wisc.edu**).** Rate of spring or latewood in the annual ring has an important impact on surface roughness. In addition to these, shakes on wood, cell deflections, torn off fibers, fiber length, knot and fiber bents are the factors which increase roughness (Sieminski and Skarzynska**,** 1989). Shear direction also affects the amount of roughness. Tangential sections make better surfaces than radial sections (Gürleyen, 1998).

To make the surface of the wood smooth, shearing, rasping and sanding may be done. Processes applied on wood surfaces influence the surface smoothness. Besides processing factors which takes place during the production has an effect on smoothness. In figure 14, Page 23; the effects of sand sizes and sanding, shearing with circular and band saw on surface roughness is given.

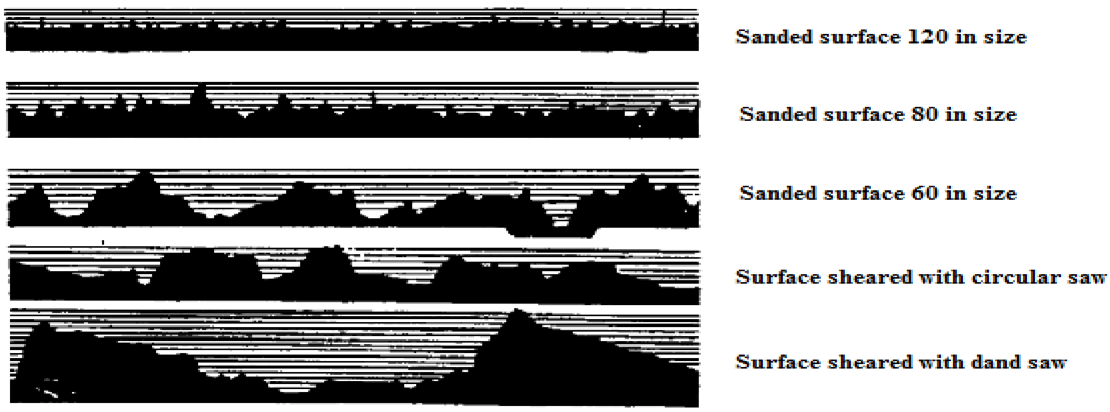


Figure 14: Surface of fagus orientalis after different processing methods (Gürleyen, 1998).

In wood materials upper surface processes, the adhesive between the wooden material and the other materials such as PC or PMMA is significant. Essential information about adhesion is given below.

Adhesives are materials designed to hold materials together by surface attraction, often as alternatives to mechanical fastening systems. Adhesives come in several forms - thin liquids, thick pastes, films, powders, pre-applied on tapes, or solids that must be melted. Adhesives can be designed with a wide range of strengths, all the way from weak temporary adhesives for holding papers in place to high strength structural systems that bond cars and aeroplanes. In many industries, adhesives compete with mechanical fastening systems (Keohan at al., 1994) such as nuts and bolts, rivets or welding and soldering (Hashim and Loke, 2002).

Engineering and structural adhesives are distinguished from other adhesives by being high strength materials that are designed to support loads, often substantial loads. These adhesives are also often subjected to cycling high and low temperatures and aggressive fluids or the weather. In general they are used for the bonding of rigid structures, although some degree of flexibility or toughness is often desirable in the adhesives to counter the effects of movement, impact or vibration. The most common materials bonded with structural adhesives are metals, glass, ceramics, plastics and composites. Adhesives used for bonding wood in the construction and furniture industry are often structural (Dunn, 2004).

According to Pizzi (1994), adhesion is an important physicochemical phenomenon which draws attention of many scientists dealing with various fields of science. Aydın et al. (2001); it is stated by Debye in 1926 about adhesion that forces between two molecules are formed by a universal gravity which increases as the distance between these two molecules shortens until they touch each other.

Carpenter (1999) defined adhesion as a state in which dissimilar surfaces touch each other and interface forces are kept together. Carpenter (1999) also pointed out that interface forces may be formed from their linkage force to one another. As it is thought that there is an external force different from adhesion (i.e. defined as the gravity force of molecules from two different substances), presence of a force known as cohesion (i.e. gravity force between the molecules of a substance) should not be ignored.

While Carpenter (1999) defines cohesion as a state in which molecules of a substance are hold together by primary and secondary valency forces; it is defined as an interlock among forces that influents cohesion, gravity forces between molecules (Van der Walls forces) and polymer molecules. Adhesion molecules with cohesion molecules are demonstrated in figure 15, Page 25.

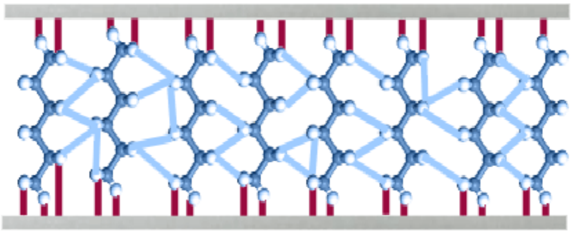


Figure 15: Adhesion and cohesion forces (http://www.adhesiveandglue.com).

For a good adhesion Walinder (2000) stated that both adhesion and cohesion forces should have high capacity. According to Pizzi (1994) in an adhesion system, there are five theories in an adhesion mechanism:

- Mechanical interlocking theory
- Absorption theory (adsorption theory or specific adhesion)
- Diffusion theory
- Electrostatic theory
- Covalent chemical bonding theory

In mechanical interlocking theory, two surfaces are joined by a liquid adhesive inserted into the permeable surface. When the liquid adhesive concretes, interlocking process is completed. It points out the adhesion that occurs as a result of physical bonding on the wood surface upon which the liquid will be applied. It is known that the best adhesion takes places when the liquid penetrates into the cells under the surface (Çakıcıer, 2007).

Gent and Hamed (1983) say that adhesion starts with applying a liquid onto a solid materials surface and then it starts damping the surface. For a strong bonding to occur, liquid molecules inserts into the gaps. They told that mechanical bonding should take place for a liquid material to harden. Absorption theory consists of atom and molecule forces effective on an interface surface, on condition that they have a close connection. These are explained as secondary forces (Van der Walls and hydrogen bond and electrostatic forces) and primary forces (ion, covalent and metallic bonding).

Van der Walls forces, that are effective on molecular structure of wood and formation of adhesive polymer bond, are made up of three gravity forces among molecules. These forces are (Aydın et al., 2001):

- ***Dipole-dipole forces***, they are positive and negative charged polar molecules and they have a high gravity for other polar molecules.
- ***Dispersion (London) forces*** consist of non-polar molecules low gravity for each other.
- ***Hydrojen bonds*;** they are a special type of dipole-dipole forces. They state the high gravity between positive charged hydrogen atoms of a polar molecule and electronegative atom of a molecule.

It was reported by Vicki (1999) that hydrogen bonds are effective on the gravity of hemi-cellulose and cellulose molecules rich in polar hydroxyl groups, and polar liquid polymers. According to Carpenter (1999), it is based upon long chain molecule's penetration into the solid material partially or entirely on molecular surface. Diffusion level of the liquid molecules into the material that they are applied on is important. It depends on free volume and molecular suitability of the material that will be applied. Molecular suitability depends on the reaction among the functional groups existing in varied polymers in the liquid and material (Aydın et al., 2001).

Pizzi (1994) states that in case of two non-similar materials' touch to each other, two-layer electrostatic charge which enables the adhesion on interface will be formed. No experimental evidence has been found proving the contribution of this theory into wood adhesion (Aydın, 2004).

According to Pizzi (1994) covalent bonding theory shows the adhesion between wood and liquid as a result of a bond formation. In case of formation of covalent bonding, it is believed that strong and durable adhesions will occur. It is known that wood surface has many functional groups. Thus, covalent adhesion is more favorable for wood than any other material. Covalent chemical bonding occurs with the reaction between liquids containing isocyonate and hydroxyl groups in lignin.

According to Vick (1999), covalent chemical bond forms as a result of the interaction between the atom molecules of the units forming bonds with hydrogen by sharing their electrons. Covalent chemical bonding is two hydrogen atoms' share of the electrons to form a Hydrogen Molecule. These covalent bonds are the strongest chemical bonds and they are 11 times more resistant compared to hydrogen bond (Kendall, 1994; Aydın et al., 2001). Kazayawoko (1996) demonstrated the theories defined for adhesion mechanisms in Figure 16, Page 27.

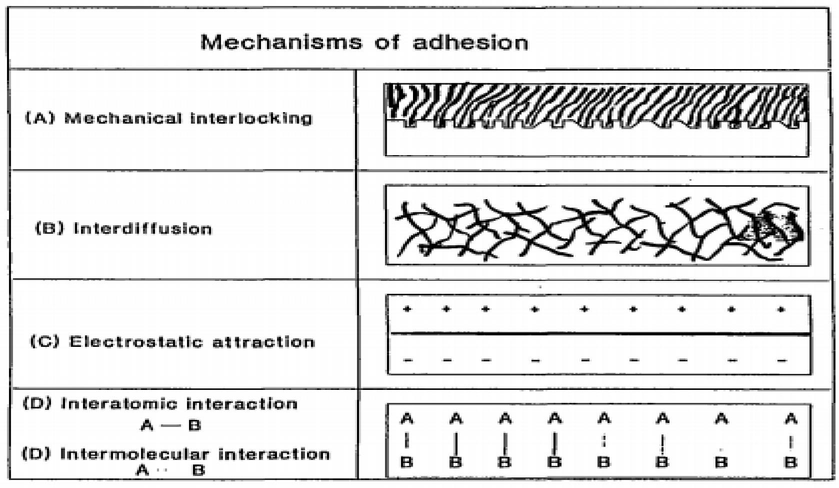


Figure 16: Schematic construction of the mechanisms of adhesion (Kazayawoko, 1996).

According to Aydın (2004), a good adhesion requires a good preliminary preparation. Adhesion resistance will be high when filth on the surface is cleaned with an upper surface process. Adhesion strength may be enhanced by the ways below:

- Degreasing and cleaning the surface by using mechanical grinding,
- Make an active surface by coating with primer,
- Changing the surface activity by grinding, corona process, low plasma treatment etc.

Sernek (2001) indicated that after extractive materials are removed from the surface, warming ability of some wood types will increase. However, he restated that it is not true for all types of trees. Wood resin's coming up onto the surface is one of the reasons decreasing warming ability. It is known that heartwood of both leafy and coniferous trees contains more extractive substance compared to sapwood. Hence, it shows that heartwoods are more sensitive to decrease in adhesion surfaces' activity (inactivation).

It was reported by Christiansen (1990) that on some types of trees (i.e. pine, duglas abies, spruce and larch) which have resin canals, it is possible to see resin debris in time; that on leafy trees india rubber, oleo resin, phenolic substances and polysaccharide mass on the surface during drying process and prevent adhesion. It is also reported that extractive substances may lead to changes on warming ability of wood surface in time.

According to Aydin (2004) extractive substances may prevent the formation of a good adhesion. Besides there is no clear result showing sensitivity to inactivation (i.e. decrease in activity for adhesion) caused by resins and other extractive substances on wood surfaces. While some researchers state the relation between the amount of extractive substance on wood surface and adhesion quality, some couldn’t put forward a clear relation. According to Williams and Feist (1999) ageing on surface occurs on the surfaces of all organic materials consisting of wood and polish and varnish on wood surfaces.

Bonding performances of five different adhesives (i.e epoxy adhesive, acrylic adhesive, chloroprne adhesive, WD2104 adhesive for bonding plastic, PVAc adhesive) to polyvinyl chloride (PVC)/wood flour composites (briefly referred to PVC-based wood-plastic composites (WPC) were tested by Cheng (2013), in order to determine which adhesive was suitable to bond PVC-based WPC. According to that results showed that bonding properties of PVC-based WPC joint, bonded with epoxy adhesive were highest compared to the other adhesives used in that study.

It was evaluated that the performance *of Eucalyptus benthamii* Maiden et Cambage wood for the production of edge glued panels by Martins et al (2013). Wood pieces with planed and sanded surfaces were bonded using cross-linking polyvinyl acetate (PVAc) and polyurethane (PUR) based adhesives, at pressures of 0.7 MPa and 1.0 MPa. According to the results, the pressure and surface preparation variables did not inñuence the glue-line shear strength of the adhesive PVAc, whereas for the PUR adhesive strength was infiuenced by the pressures and machining used. All treatments met the minimum values required by the standard; however, the highest bonding strength was found in the sample glued with PUR adhesive at a pressure of 1.0 MPa and sanded surface. The highest modulus of rupture was obtained in the samples glued using PVAc, while the modulus of elasticity was not affected by the type of adhesive used.

2.1. Surface Free Energy

2.1.1. Surface Free Energy of Wood

According to Baldan (2012) and Qin et al (2014), the concept of wettability is a measure for easiness and efficiency of how a liquid spreads over a solid surface. In case of a wood material, wettability is an important parameter that provides many of information on the interaction between the surface of wood and liquids (Gindl et al., 2004; Rathke and Sinn, 2013), which also has a significant influence on the bonding strength of wood composites. Adequate wetting of the wood surface by an aqueous resin solution is a fundamental requirement for a generation of strong adhesive joints (Jennings, et al., 2005).

The wettability of surface depends on many factors, both physical and chemical. Surface roughness has a significant influence on the contact angle even for seemingly smooth surfaces at macroscopic scale or at nano-scale, and is important for many practical wetting and spreading processes (Chau, et al., 2009). The surface of porous material affects measured values of contact angle due to differences in surface texture and absorption effects. As we know, wood is a complex material, and its wettability depends on many factors, for example, wood species, type of wood, biological attacks, grain orientation and aging of an exposed surface. The direction in which wood is cut is the reason for the diversity of wood surfaces, because cell structures and directions vary along different planes and the position of measurement point whether it is in late or earlywood (Winfield, et al., 2001).

Gindl and workfriends (2001) defined the surface free energy of wood, similar to wettability, is a useful parameter that has often been correlated with the biological interactions of wood. Surface free energy can be calculated by many methods based on the contact angle of liquids on wood. Recently, as well as in the past, much research has been undertaken examining differences in wood surface free energy in relation to the properties of porosity and anisotropy. It was found that the species, surface roughness, pH value, and aging time all influenced surface free energy (Cao, et al., 2005, Little, et al., 2013). The dynamic wetting behavior of different wood species using the dynamic contact angle method and studied and compared the methods for calculating surface free energy as well (Walinder and Gardner 2002).

The effect of aging time on surface free energy is significant using the contact angle measurements combined with X-ray photoelectron spectroscopy. They also concluded that the acidity of wood compared with surface energy components is a good relative measure for the classical acidity and pH value between different wood species (Gindl, et al., 2004).

It was reported by Shi and Gardner (2001) when a liquid wets wood, three effects can be observed: 1) the formation of an interface between the wood surface and the liquid drop, 2) the spreading of the drop on the wood, and 3) the penetration of the liquid into the wood. Wetting of wood by a liquid is a complex process involving a series of physicochemical processes. Therefore, studying the wetting process may be more meaningful than studying only the initial equilibrium contact angle. There are also many factors (such as surface tension phenomena and viscosity of liquids, wood aging, drying processing, and defects) that influence penetration. Contact angle measurements with a sessile drop method represent a direct method for evaluating the wetting process (Huang, et al., 2012).

2.1.2. Surface Free Energy of Plastics (acrylic)

Bonding a plastic material to itself or another plastic material may vary by the type of plastic material, ingredients of the adhesive and its resistance to chemicals. Therefore, different methods are applied on the surface of the material to bond them. Generally, surface applications are made up of 4 processes; sweeping, abrasion, cross bonding and chemical surface modification. Beside main reason of the problems in bonding surfaces is the low surface energy. Monomers in thermoplastics are bonded with Van Der Waals bond to be able to form macromolecule. Low surface energy stems from being able to break the bond with little force (Şekercioğlu and Kaner, 2013).

Surface energy in plastic materials is determined by intermolecular force. Boiling and melting points of the material have an effect on the formation of these forces. During the bonding process of the plastic surfaces, different affinities form between the surface and adhesive (Şekercioğlu and Kaner, 2013).

There is an interface made up with the bond of atoms or molecules of two materials in solid and liquid phases. Structures in these two phases scatter in them and cause the formation of a new layer. Atoms can transmit from one phase to another by means of this interface. There is gravitation on the surface formed by liquid molecules. When all the gravitation influencing the surface is added, it equals to zero. This force resists the diffusion of liquids on the surface. This energy is called surface energy. A material's surface energy is in proportion to the resistance it has for a material bonded on it. Wettability test applied on the material and measured contact angle enable researcher to find the surface energy value. Materials may be categorized as low surface energy and high surface energy in the point of surface energy. Polymers known as organic compounds are low surface energy materials (Kovan and Şekercioğlu, 2005).

Their surface energy values are generally under $100mJ/m^2$. Metal, metal Oxide and ceramic materials are known as high surface energy materials, and their energy values are above $500\ mJ/m^2$. Parametric values which form between contact angle occuring during the contact of polymer materials and critical surface tension angle between plastic materials give information about contact condition. Formations of contact angle and critical surface tension have different values in different liquids used between plastic materials. Critical surface tension value and contact angle are important parameters to be able to characterize a low surface energy surface (Goss, 2010).

Bonding quality is enabled by good adhesion and cohesion bonds. In some cases big and rough surface area is not good enough to adhesion. It is important to fill the micron-size gaps that cause roughness correctly for rough materials. Surface energies and diffision (wettability) have a great importance on adhesion. Surface energy is a term evaluated with surface contact angle (Goss, 2010).

There is a mechanical resistance to bonding in the adhesion process. A conditioning work is done with a process on the surface that will be bonded but during this process any change does not ocur in the density or general quality of material (Kinloch, 1987). An increase in the plastic surface energy occurs with polymer chain conjugation. For halogenated polymers such as fluoropolymers when surface modifications give out an important halogen, chlorine and fluorine atom, it involves the removal of surface molecules (Ebnesajjad, 2006). Generally, surface processes may be seen as an energy transmission for plastic surface. Some special adhesives are manifactured to overcome the low surface energy between plastic materials. Especially epoxy-poluamide adhesives ensure good results on plastic material surfaces. In special cases, some preliminary processes are applied on the surfaces before bonding and in some of them bonding may be done without any process (Chan, 1993). However, some materials such as PTFE, PE, PP, PC, PMMA do not bond without preliminary processes because of their low surface energy. During the adhesion process of plastic materials, only the surfaces intended to be bonded should be prepared suitably for good bonding process. To be able to increase the low surface energy plastic materials have, it is aimed to have better surfaces for bonding by increasing the wettability via the applications on the material. In general it is maty to be said that the reason for surface processes is transferring energy on the surface of plastic material.

Several processes were developed to modificate the surface without using mechanical wearing or liquid based chemical techniques. These were especially developed to have a suitable chemical modification on plastic materials with physically stimulated and oxidative processes. Some of these processes reveal other chemical elements during the modification as well (TSE EN, 2007). Surface energy and bonding quality of a plastic material may be increased with mechanical wearing, chemical etching, flame etching, corona and plasma process. In this study, mechanical wearing technique was applied on plastic material surfaces (PC and PMMA).

Mechanical wearing may be defined as roughening and sanding process on plastic material surfaces. The aim of mechanical wearing on plastic materials is to increase the contact surface of loose and unstable polymers. Besides, if there is a coating or membrane layer, this technique will not be efficient. With a definite roughness amount on the surface of the material, it is possible for the adhesive to scatter densely and find a large area to bond. In this way, chemical bond due to form will be stronger. A suitable surface for bonding may be obtained with proper sand considering the structure of the plastic material and intended surface roughness amount. Surface to be sanded and the quality of the sand that will be used in the process should match each other (Chan, 1993).

3. THE PURPOSE OF THE STUDY

Away the wood and related industries is working with materials; and clearly we see the influence of the plastic in the late 20th century and in the 21st. Beside we see the role of wood in decorative because of its elegance and the effect of making a sense of naturalism. So the combination of economy and glory, or in other way, the post-modernism of the 21st century is made a question of how we can handle both sides simultaneously. Nowadays is not the mass and speed competition like 80s. We are facing the new challenges of customer satisfaction with variable needs and extremely variable demand (wills). We have to overcome to answer the quality specification that market needs, by technical specifications. In wood and furniture industry in order to make a good relationship between quality and technology, we undertook a part that is fundamental; we tried to present the optimum alternatives to a producer who has the will of compete in this competitive environment. We chose the elements that basically have the main influences in manufacturing processes of woods and decorative; there are variant woods, plastics, joints and adhesives that play those roles.

The Aim of the Thesis

In this research we study some combinations of materials in decorative industry; wood material, the adhesive, and the plastic material. The combination of plastic and wood could creat aesthetic designs. So we chose some kinds of wood and some kinds of plastic and of course adhesive materials to stitch them together and make aesthetic and strong panels. To make it happen we chose wood materials from Czech Republic and Turkey (i.e. Oak and Spruce from Czech Republic, Oak, Spruce, Cypress and Chestnut from Turkey), and plastic materials (i.e. PC, PMMA) due to their bearing and hardness properties. We also used adhesives as common in industry (i.e. Solvent Adhesive, PUR Adhesive, Epoxy 1200 Adhesive and PVAc Adhesive) to form our combinations.

By designing tests and experiments we are trying to declare about the strengths and other technical properties of the final crop, as the economical, financial and environmantal aspects of the processes are not considered in our study.

4. TESTING MATERIALS

4.1. Wood Materials

4.1.1 Oak (Quercus petreae L.)

Quercus petreae (white oak); there are bright pleas in radial profile or pith beam of light in lines. Blank parts among the thick pith beams are quiet many in number. Accurate dry density is 0.54 g/cm^3 (Örs and Keskin, 2011); pith beams are the most clearly seen in oak trees. Images of pith beams in tangential profile are like dark colored lines. In spring wood there are 4 or 5 rows of big and round cells. In autumn texture, cells get smaller and tighter. Annual rings may be seen clearly. They have proof to the deforming effects of air and humidity. Because of the vast amount of tannin in it, oak tree is the best polished tree. Oak wood is used in the manufacture of doors, windows, stairs, in flooring (parquets) and coating (Bozkurt, 1982).

4.1.2 Chestnut (Castanea sativa Mill.)

The size of the cells in spring texture is able to be seen easily. Cells in autumn texture are so small that they are not seen by naked eye. Their pith beams are so thin and they can’t be seen by naked eye. They are tough, densely packed and flexible. Live wood is narrow. Accurate dry density is 0.48 g/cm^3 and capacity density amount is 0.47 g/cm^3 (Örs and Keskin, 2001). Its sapwood is narrow (2-5 ring wide) and yellowish white. Its heartwood is light Brown when it is fresh and later it turns into deep brown. Its wood is ringed with tracheas and the pith beams are not explicit (Akyüz, 1997; Merev, 1998). In chestnut wood, macroscopically sapwood is very narrow, brownish white and grey; heartwood is grey-yellow and pastel brown when fresh. Its color darkens after cutting. Annual rings are explicit as they have large tracheas. Pith beams are thin and not explicit. Microscopically, they have a ringed trachea layout. Spring wood tracheas are very large, oval and their radial caliber is 500 μ, tangential caliber is 300 μ. Their pith beams are singlerow. Libriform fibers and fiber tracheids form the main texture (Bozkurt, 1992). Due to the long fiber structure it may be twisted easily. It works little and it is processed easily. It makes up good joints with nails, screw and glue. In woodwork, it is used in bridge pipers and duck legs; in furniture manufacturing as solid and coating (Bozkurt and Erdin, 1997).

4.1.3 Spruce (Picea orientalis)

There is no difference in color in live and pith woods. Yellowish white is in the quality of mature wood. Annual ring margin is clear. Spring and summer wood transition is slow, resin canal is commonly found in summer wood. Pith beams are thin and are not seen by naked eye. They are of medium weight. Tarheid caliber is 20 to 40 um, height is 1.3 to 4.3 mm; pith beams are sequential and in a non-homogeneous quality. Supply gaps are piceoid type. Epithelial cells surrounding longtitudal resin canals have thick membranes (Nusret, et al., 2001).

4.1.4 Cypress *(Cupressus L.)*

Its wood is light brownish yellow. Spring wood and latewood are not so distinctive. In some sorts heart-wood and sapwood is hardly recognized. Piths are very thin; they are just recognized by loop. It has wood that is light, easily processed, when processed gives a smooth surface, durable and odorous. It is used in furniture production, buildings, manufacturing of fences for parks and gardens carpentry as well as telephone and telegraph poles. It is eligible for underwater building, too. Yet, because of the odorous wood, it is inconvenient for packing and encasing dry food and dairy products (Yalıntırık and Efe, 1994).

4.2. Plastic Materials

4.2.1 Polycarbonates (PC)

Polycarbonate (PC) was first developed in 1953 by Bayer in Germany and General Electric in the US independently. Its most popular trade name is LEXAN. PC is one of the high performance heterochain polymeric materials that comprise the family of "engineering thermoplastics". PC is a good material choice in industry not only due to its characteristics, but also because its processing is environmentally friendly, and it can be recycled. Molecular structure of polycarbonate is given in the Figure 17, Page 35.

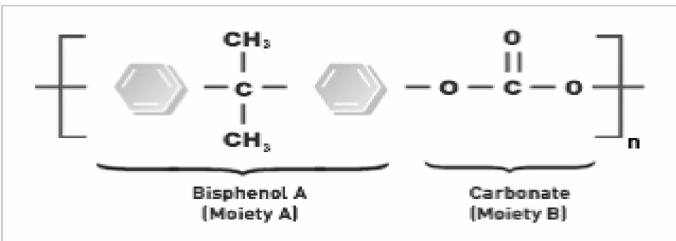


Figure 17: Molecular structure of polycarbonate (http://www.lg-dow.com).

A polycarbonate molecule is composed by a Bisphenol A part and a carbonate group. Bisphenol A contains two aromatic rings, which are responsible for PC's stiff backbone.

The Bisphenol A group also contributes to PC's inability to crystallize. This amorphous structure gives the polymer its particular transparency. The Characteristic high glass transition temperature (Tg = 145 ºC) of PC is caused by the minimal molecular rotation about the bonds.

Polycarbonate is transformed from pellets into the desired shape for its intended application by melting the polycarbonate and forcing it under pressure into a mold or die to give it the desired shape depending on the application. This process is repeated thousands of times. It maintains good mechanical properties between -4.4 °C and 137.7 °C.

High strength makes it resistant to impact and fracture. It can be easily colored, it's non-toxic, and can be absolutely transparent up to 2 In. in width. PC also features high electrical and heat resistance. It is biologically inert. Readily recyclable and cost effective (Rodriguez, et al., 2003).

PC's outstanding strength makes it suitable for bullet-resistant or shatter-resistant glass applications. PC's relatively low weight in comparison to other high strength materials and its high ductility make it attractive to be used in lenses and windows. It has also been used as a flame retardant and an electrical insulator. Small filters for the extrusion of small particles, used in CD's, DVD's. Automotive, cell phone, laptop parts (http://www.eng.buffalo.edu).

4.2.2. Polymethylmethacrylate (PMMA)

Origin of the method is deriving methyl methacrylate from acrylate esters and then polymerization of it. For this, firstly, taken out of acetone and hydrocyanic acid, with the assistance of cyanhydrin and sulphate acid metachoromatic sulphate is derived in heat:

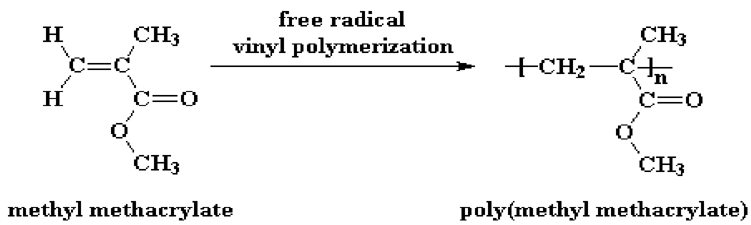


Figure 18: Molecular structure of polymethylmethacrylate (https://www.google.cz).

Acetone, cyanhydrine, metachoromatic sulphate, methyl methacrylate, methyl methacrylate monomer is transmitted into a casting polymer via suspension polymerization.Granule is released to the market in the shape of a board or reactive viscous lacquer. (Viscous lacquer is in the state of monomer.) Transforming of it into a board is carried out by cell-casting or extrusion methods. In cell casting method, to the cell where two parallel polished glasses are situated, reactive viscous lacquer casting is done. Polymerization is completed in mold. In manufacturing boards by extrusion, granule polymer is used. Acrylic boards derived by using both methods have some differences that we will look into in properties section.

PMMA is a linear thermoplastic material. In terms of optics it is perfect. Being transparent and clear provides a benefit to PMMA among the plastic materials. It’s refractive index is between 1.49 and 1.52. White light transmittance is 92%, dampness value is 1 to 3%. It is a material whose optic features aren’t affected by daylight, open air conditions and water. PMMA may be colored as transparent or opaque. However, colorful materials made of poor quality pigments may be affected by open air conditions in time. Granules of some PMMA products have the quality of UV absorption. Boards gained as moldings are in size of 3x3.65 m, 0.76-108 mm thick; extrusion boards are 3x180 m in size and maximum 9.5 mm thick. Boards gained via molding are more transparent than others and their surface smoothness is better. Dimensional stability with mechanical and thermal features is very descent. Pull-off strength with 700 kg/cm^2 is equal to styrene copolymer with impact resistance. Density may be between the values of 1.17-1.28 gr/cm^3. In terms of their types inflection with heat is between the temperatures of 73-97 °C. It’s design is manufactured by shaping via injection, extrusion, molding and pressure heat (for boards). Acrylic board pieces are formed with hot resistance wire or by melting it in water. Boards may be cut off by scratching with sharp tip and then inclining. When sticking is required Carbon tetrachloride or dispersion in chloroform 8% of its own material may be useful.

As PMMA is flammable necessary precaution should be taken during production, shipping, storing and usage. PMMA's main usage areas are blinkers in automotive industry, home or office illumination accessories, advertisement scripts and bill boards, different ornaments, stationary supplies as rulers and miters, lenses, sun shades for buildings, decoration stuff and non-blanching watch glasses **(**http://plastik dunyasi. blogcu.com**).**

4.3 Adhesives

4.3.1 Polyurethane Adhesive

Low viscosity liquid to high viscosity mastic; supplied as one-part or two-part systems; completely reactive; color varies from clear to brown; colorless bondline. Adhesive applied directly to one surface, preferably to watermisted surface; reactive with moisture on surface and in air; cures at room temperature; high pressure required, but mastic required only pressure from nailing. High dry and wet strength; resistant to water and damp atmosphere; limited resistance to prolonged and repeated wetting and drying; gap-filling General purpose home and shop; construction adhesive for panelized floor and wall systems; laminating plywood to metal and plastic sheet materials; specialty laminates; installation of gypsum board (Madison, 2010).

4.3.2 Epoxy (1200) Adhesive

Epoxy adhesives and coatings are widely used because of their good environmental resistance and the ability to bond to a wide variety of surfaces, including wood, metals, plastics, ceramics, and concrete. They are less commonly used in wood bonding because they cost more than most wood adhesives, and in some cases, their durability is limited. On the other hand, they are structural adhesives that cure at ambient temperatures, have good gap filling ability, and do bond to many other surfaces, while most wood adhesives require heat cure, are not gap filling and do not bond well to other substrates. Thus, epoxies continue to be examined for their use in bonding wood to other materials and for in-place repair of damaged wood structural members. Besides cost, a main limitation of epoxies is their lack of acceptance for applications that require durable bonds (American Institute of Timber Constrution 1990).

Although there are some cases of self-polymerization under the influence of acid or tertiary amine catalysts, most epoxies have an alternating ABABAB backbone that is highly crosslinked, usually using the multi-functionality of the hardener. The standard terminology is for the epoxy to be called the resin and the other component that crosslinks the epoxy to be called the hardener (Wisconsin, 2010). The formulation is expressed as parts per hundred resins (phr) with the weight of the epoxy as 100 and the rest of the components given relative to the epoxy weight. The hardener is anything that will react with the epoxy groups, including amines, thiols, hydroxides, and acid groups, but amines are the most common hardeners.

The most common epoxy resin is the diglycidly ether of a bisphenol A (DGEBA), although other multi-functional epoxies can be used. This is then reacted with epichlorohydrin under basic conditions to yield the DGEBA molecule and sodium chloride. The removal of the salt is especially important in electronic applications to minimize metal corrosion by the chloride. The DGEBA epoxies vary in molecular weight due to polymerization through the epoxy groups. Bis-F resins have also been used; these are similar to the bis-A resins except that formaldehyde is used in place of acetone for the condensation. More flexible resins can be made using epoxidized oils and other non-aromatic epoxides. Brominated epoxies are often used for fire resistance.

In contrast to the limited types of epoxies, the hardeners or curatives have a wide variety of chemical structures. The hardeners have active hydrogen attached to a nucleophile, which essentially adds across the epoxy group. For less nucleophlic groups, addition of a tertiary amine that interacts with the oxygen atom in the epoxy makes the epoxy ring easier to open. This continues until all the active hydrogens are reacted with epoxide or the epoxide is used up. Thus, for amine with two reactive hydrogens on nitrogen, two epoxy groups can react, but the second addition is much slower. For formulating the ratio of hardener, the equivalent weight of the hardener is calculated by dividing its molecular weight by the number of active hydrogens (Roger, 2005).

4.3.3 PVAc Adhesive

PVAc adhesive, besides the positive qualities of being able to be applied cold, being applied easily, stiffening quickly, being inodorous and inflammable and not wearing out the hacks when it is processed, has a limited mechanical strength because it melts with the increasing heat after the application and it doesn't fulfill the connector function as it is required.

It is enough for a good adhesion to put the adhesive on just one part of the surfaces that will be attached to each other and use 200 gr/m^2 adhesive with respect to the kind of wood and the state of the surface (Örs, 1987). According to the principals indicated in TS 3891, PVAc adhesive should has the density of 1.1 gr/cm^3 , viscosity between 160 and 200 cps, 5 Ph value, 3% cinder, 6-15% humidity in adhesion of solid wood. Pressing time is 20 minutes in cold adhesion with the temperature 20 ^{0}C, 2 minutes with the temperature 80 ^{0}C and it is suggested to repose it in the pressing platform until it cools down (Örs, et al., 2000).

4.3.4 Solvent adhesive

Basic material of contact adhesive is artificial rubber. Artificial rubber used in production of adhesive is obtained from vinylacetylene by chemical methods. After contact adhesive is rubbed on the surface, it is aired for a while. Waiting time may change depending on the chemical structure of the adhesive used. Adhesive should be used according to the recommendations of the producing company. Airing time may vary between 10 to 15 minutes. Flick formed in the joint of contact adhesive is flexible. It is resistant to water. It has thermoplastic feature. It softens in 60-70 ^{0}C. When it is mixed with its special stiffener contact adhesive's resistance to heat increases. 250 grams of adhesive applied on 1 square meter is usually enough. Depending on the adhesive's and adherent material's characteristic, pressing machine's pressure varies between 6 and 15 kg/cm^2 and pressing time varies between 1 and 5 minutes (Şanıvar and Zorlu, 1991).

5. TESTİNG EQUIPMANTS

In this part, testing equipments used in this study are defined and their features are introduced.

5.1 Surface Roughness Tester

In measuring surface roughness, *TIME TR-200* surface roughness tester, which can measure the sequential surface changes, had been used. Technical features of the device are given in Table 1, Page 41 and pictures of the decive are given in the figure 19, Page 41.

Table 1: Properties of surface roughness tester (Anonym TR-200).

Type	**TR-200**
Measurement parameters	Ra, Rz, Ry, Rq, Rt, Rp, Rmaks, Rm, R3z, S, Sm, Sk, tp
Measuring accuracy	0.01-0.04 µm
Measuring standard	ISO 4287, DIN 4768, JIS B601, ANSI B46.1
Power supply	Li-ion battery rechargeable
Measuring legth	Automatic, 0.25 mm, 0.8 mm, 2.5 mm
Number of measurement	1-5 (cut-offs) (selectable)
Suitable working temperature and humidity	0-40ºC ve <%90 relative humidity
Dimensions and weight	140x52x48 mm and 500 grams
Response	Transfer to LCD screen, printer or PC

Average roughness rate of center line that is between convex and concave is shown as (Ra).

Figure 19: Surface roughness tester (TIME Group, 2005). Photo: Okcu, O.

5.2 Precision Scales (0.01g)

Prepared samples for adhesion test before and after adhesion, in room temperature, hot chamber and cool chamber. A sample scale used is shown in Figure 20, Page 42 and technical properties are given in Table 2, Page 42.

Table 2: Technical properties of scales used in measurement.

Capacity	50g / 1.7637oz / 1.6075ozt / 32.15dwt / 771.62gn / 250ct
Readability	0.001g / 0.0001oz / 0.0001ozt / 0.001dwt / 0.02gn / 0.005ct
Linearity	±2d
Repeatability	±2d
Stabilization Time	3-5 seconds
Calibration Weight	50g (included)
Scale Dimensions	5.2 x 3.7 x 2.3"
Platform Dimensions	2.7" Diameter
Power	4 x AAA Alkaline Batteries or 6V 100mA Adapter (included)

Figure 20: 0.01 capable of precision measurement scales (http://www.awscales.com). Photo: Okcu, O.

5.3 Pressing machine

Samples prepared to use in the experiments were glued and pressed for a good bonding process. For this process, pressing machine of which technical properties are given in Table 3, Page 43 and picture given in Figure 20, Page 43 was used.

Table 3: Tehnical properties of pressing machine **(**http://www.inye.com**).**

Area of hot disc	Travel	Electric heat power	Max. output
40*50cm	200mm	5.4kw	5Ton
Diameter of cylinder	Max. distance between upper and lower molds	Pressure of pump	Motor
∮100mm	180mm	70kg/cm^2	2HP
Temperature	Time	Machine dimensions	Weight
Max.250℃	1sec~99hr	105*73*166cm	545kg

Figure 21: Pressing machine. Photo: Okcu, O.

5.4. Tensile Testing machine

The 3360 Series Testing Systems are tension and/or compression applications where tests are less than 50 kN (11.250 lbf). Models are available in load force capacities of 5, 10, 30, and 50 kN. From routine, standardized QC tests to general purpose mechanical testing (http://www.instron.us). Features;

- 100:1 force range (i.e. use the load cell to 1.0% of capacity with no loss of accuracy)
- Load accuracy of 0.5% of indicated load
- 100 Hz data acquisition rate
- Full software control (cyclic capability optional)
- Optional TouchPanel control

- Automatic transducer recognition
- Thousands of optional grips and fixtures
- Optional temperature chambers
- Choice of three colors (Red, Blue, or Grey)
- Full CE compliance.Testing machine is shown in the figure 21.

Figure 22: Instron 3300 tensile testing machine. Photo: Okcu, O.

6. TESTİNG METHODS

6.1. Laminated Method

In the preparation of tested samples; oak, chestnut, cypress, spruce woods are used. Samples are chosen randomly from timber manufacturers in Brno of Czech Republic and Çanakkale Province of Turkey. 5mm thick papel coating are obtained from pieces which don't consist of any growth deficiency by using intercept method. Before the adhesion process, weight of all the samples are weighed on 0.01 mm delicate analytical balance then samples are kept in 103±2 ^{0}C hot drying oven until they reach their regular weight.

In accordance with the principals of CSN EN 302-1, 5 mm thick (papel coating) are cut 20 mm wide and 80 mm long, and all the wooden samples are kept until they reach 20 ± 2 °C heat and 12% humidity in climatization cabinets with relative humidity of 65±3 %.

Plastic based materials were used in thickness 5 mm Polymetilmetacralat (PMMA) and polycarbonate (PC). According to principals of CSN EN 301-1 sheets are cut 20 mm wide and 80 mm long.

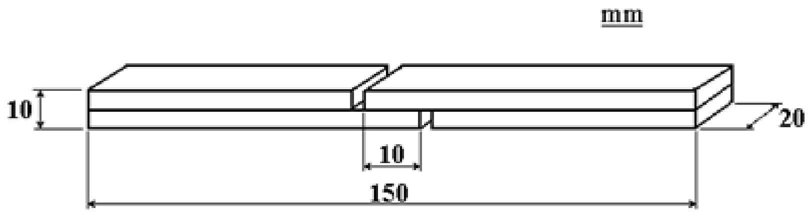


Figure 23: CSN EN 302-1 specimen.

For each adhesion sample demonstrated in Figure 23, 960 samples are used to make up the numbers in the Table 4, Page 46.

Table 4: Number of samples used in the adhesion test.

Wood Materials	Layers	After bonding of contations	Adhesives				
			Solvent	PUR	Epoxy 1200	PVAc	Total
Cz oak	Wood*wood	Room temperature	10	10	10	10	40
	Wood*PMMC	Room temperature	10	10	10	10	40
	Wood*PC	Room temperature	10	10	10	10	40
Cz spruce	Wood *wood	Room temperature	10	10	10	10	40
	Wood*PMMC	Room temperature	10	10	10	10	40
	Wood*PC	Room temperature	10	10	10	10	40
T oak, T spruce, T cypress andT chestnut	Wood*wood	Room temperature	-	-	4*10	4*10	80
		High Temperature	-	-	4*10	4*10	80
		The freezer	-	-	4*10	4*10	80
	Wood*PMMC	Room temperature	-	-	4*10	4*10	80
		High Temperature	-	-	4*10	4*10	80
		The freezer	-	-	4*10	4*10	80
	Wood*PC	Room temperature	-	-	4*10	4*10	80
		High temperature	-	-	4*10	4*10	80
		The freezer	-	-	4*10	4*10	80
Total							960

6.2. Surface Roughness Measurement

In this study, there are 6 kinds of trees in this research in which Czech and Turkish woods are compared according to their surface roughness. Two of them are spruce which is among the ones growing up in Czech Republic and they are coniferous trees. The other consists of broad-leafed oak tree. Turkish wood's samples consist of spruce and cypress from coniferous family, and oak and chestnut from broad-leafed tree's family. Samples were rasped with feed rate of 7m/min and wedge angle of knives was 36^{o}. After that, measurements were taken from these samples in parallel and cross directions to fibers and the differences between these measurements were analyzed.

Ra rates are determined according to the format implemented in TS 971, TS 930 and TS 6956. Complying with the principles of ISO 4287, testing is done on samples from every type of tree on ten points and five different points vertical and parallel to the fibers.

Measurement was carried out as demonstrated in Figure 24, Page 47 by marking samples. After setting the device 2.5 mm gauge and 5 cut-offs, gauge bar was placed between two lines that are 20 mm distant to each other. Ra measurement was done after checking and setting the parallelism of the sample and the device to the ground plain (Cakicier, 2007).

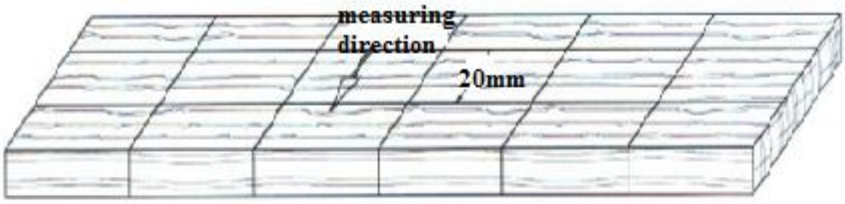


Figure 24: Test sample marking (Cakicier, 2007).

6.3. Density

To determine the dry density of wooden materials, testing samples were kept in climatization cabinets, according to CSN EN 322 and TS 2471, with temperature 103±2 ºC and relative humidity 0% until they reach their constant weight. Weight and volume of the testing samples, which have reached desired conditions, were determined. By dividing dry weight (M_0) by dry volume (V_0), dry density (D_0) of wooden materials was calculated in g/cm^3. Accordingly;

$$D_0=M_0/V_0 \text{ g/cm}^3 \quad (1)$$

To determine the air dried density of wooden material, test samples, in accordance with CSN EN 322 and TS 2471, were kept in climatization cabinets at temperature of 20±2 ºC and relative humidity of 65 % until they reach constant weight. Weight and volume of the test samples that reached the desired conditions were determined. Air-dried density (D_{12}) was calculated in g/cm^3 by dividing air-dried weight (M_{12}) by air-dried volume (V_{12}) (Duran, 2005). With reference to;

$$D_{12}=M_{12}/V_{12} \text{ g/cm}^3 \quad (2)$$

6.4. Bonding Strength Test

Test samples were kept under 20±2 ^{o}C temperature and 65±3 % relative humidity until they reach constant weight. Then, adhesive was applied to surfaces according to its type and with the rate of 200 g/m^2, after the testing samples were placed on the pressing machine; pressing pressure was set to $8kg/cm^2$ waiting time in pressing machine was set to 1 hour for polyurethane adhesive, 12 hours for epoxy1200, 1 hour for contact adhesive and 1 hour for PVAc adhesive. Sample's bonding strength was determined in accordance with principals of CSN EN 302-1. Adhesive was tried to rip off from adhesive line by applying graded pull force with 2 mm/min loading rate on the adhesion surface. By determining the maximum force (F_{max}) on breaking moment, σy i.e. adhesion strength is calculated with this Formula:

$$\Sigma y = F_{max}/A = F_{max}/axb \ N/mm^2 \quad (3)$$

Where axb= adhesion surface area (mm^2).

6.5. Post-adhesion

In this experiment, to see whether there will be differences in adhesion resistance values for post-adhesion storage conditions, three different groups were made up from testing samples; First group was kept in laboratory environment for three weeks; second group in hot drying oven for three weeks and third group in the freezer for the same period of time. Post-adhesion storage conditions of the samples are given in Table 5.

Table 5: Post-adhesion storage conditions

Conditions	Temperature(^{0}C)	Humudity (%)	Time(hours)
Room temperature	23	50	21 days x24
Cold temperature	-30	-	21 days x24
Higher temperature	70	90	21 days x24

6.5. Evaluation of Data

To determine the effects of tree species, plastic material, type of adhesive, humidity and volume of wooden material on bonding strength rates multiple analyses of variance was used. In case differences between the groups are important, Duncan test (homogeneity test) was applied for each element.

7. LABORATORY MEASUREMENTS AND STATİSTİCAL ASSESSMENT OF RESULTS

7.1. Results of Density

Exact dry density and air dry density values of the models derived to use in the study were determined. In deriving the samples density values of the plastic materials, PC and PMMA used in the production of materials were not taken into account. Six different measurements were done in determining density. (These measurements were carried on samples before adhesion process, when bonded and the adhesive was wet, after adhesive was pressed to dry and after keeping the samples for 21 days in specific conditions.)

Findings gained from the research statistically analyzed and differences between the groups were searched. Descriptive statistical avarage values of density values are given in Table 6, Page 50.

In the study, statistical analsis were carried on with “Post Hoc Tests” in SPSS 21.0.

Table 6: Descriptive statistics of wood density values (T. wood with wood or palstic).

Layers	Adhesives	Kind of measur.	N	Wood density							
				Oak		Spruce		Sypress		Chestnut	
				Mean g/cm^3	Std. Dev.	Mean g/cm^3	Std. Dev.	Mean g/cm^3	Std. Dev.	Mean g/cm^3	Std. Dev.
Wood*wood	Epoxy	Control	10	0.91	.02131	0.49	.02832	0.66	.03715	0.78	.04383
		Fresh adh.	10	0.91	.02152	0.50	.02865	0.67	.03701	0.80	.04442
		After press	10	0.92	.02147	0.50	.02872	0.67	.03696	0.79	.04417
		Roon Con.	10	0.91	.02247	0.50	.02894	0.67	.03675	0.79	.04415
		Climate	10	0.91	.02080	0.49	.02875	0.66	.03712	0.78	.04868
		The freezer	10	0.91	.02178	0.49	.03119	0.67	.03731	0.79	.04420
		Total	60	0.91	.02090	0.49	.02843	0.67	.03564	0.79	.04347
	PVAc	Control	10	0.89	.02494	0.49	.02884	0.78	.08047	0.82	.04740
		Fresh adh.	10	0.91	.02554	0.51	.02866	0.79	.07883	0.84	.04994
		After press	10	0.90	.02517	0.50	.03059	0.79	.07938	0.83	.04870
		Room Con	10	0.90	.02493	0.50	.03000	0.78	.07931	0.82	.04914
		Climate	10	0.90	.02694	0.50	.03140	0.78	.07880	0.82	.04815
		The freezer	10	0.90	.02419	0.49	.02983	0.84	.16151	0.82	.04721
		Total	60	0.90	.02459	0.50	.02932	0.79	.09658	0.82	.04689
Wood*PC	Epoxy	Control	10	0.97	.01558	0.78	.02185	0.82	.02110	0.91	.02138
		Fresh adh.	10	0.98	.01503	0.79	.02228	0.83	.02020	0.93	.02175
		After press	10	0.99	.01484	0.79	.02216	0.83	.02031	0.93	.02189
		Room Con	10	0.98	.01482	0.79	.02214	0.83	.02035	0.93	.02183
		Climate	10	0.98	.01406	0.79	.02227	0.82	.02066	0.93	.02192
		The freezer	10	0.98	.01489	0.79	.02206	0.83	.02026	0.93	.02151
		Total	60	0.98	.01461	0.79	.02160	0.83	.01995	0.92	.02146
	PVA	Control	10	0.95	.02047	0.74	.02123	0.81	.01913	0.93	.01463
		Fresh adh.	10	0.96	.02079	0.75	.02103	0.82	.01996	0.94	.01366
		After press	10	0.96	.02058	0.74	.02110	0.82	.01991	0.94	.01354
		Room Con	10	0.95	.02071	0.74	.02101	0.81	.01989	0.93	.01371
		Climate	10	0.95	.02115	0.84	.30577	0.81	.01967	0.90	.08909
		The freezer	10	0.95	.02037	0.74	.02186	0.81	.01982	0.93	.01352
		Total	60	0.95	.02000	0.76	.12595	0.81	.01928	0.93	.03864
Wood*PMMA	Epoxy	Control	10	0.93	.01942	0.73	.01944	0.78	.02014	0.85	.03837
		Fresh adh.	10	0.94	.02006	0.74	.02399	0.80	.01964	0.86	.03870
		After press	10	0.94	.01997	0.74	.02095	0.80	.01958	0.86	.03862
		Room Con	10	0.94	.01573	0.74	.02088	0.80	.01892	0.87	.03176
		Climate	10	0.94	.01972	0.74	.02278	0.79	.01949	0.86	.04455
		The freezer	10	0.94	.02011	0.74	.02097	0.80	.01974	0.86	.03858
		Total	60	0.94	.01889	0.74	.02128	0.79	.01932	0.86	.03724
	PVAc	Control	10	0.93	.02285	0.69	.01297	0.78	.01663	0.80	.03331
		Fresh adh.	10	0.94	.02334	0.70	.01318	0.79	.01713	0.81	.05019
		After press	10	0.94	.02336	0.70	.01300	0.78	.01681	0.83	.03386
		Room Con	10	0.94	.02339	0.70	.01295	0.78	.01682	0.83	.03344
		Climate	10	0.94	.02205	0.70	.01531	0.78	.01673	0.83	.04154
		The freezer	10	0.94	.02329	0.70	.01328	0.78	.01669	0.82	.03379
		Total	60	0.94	.02217	0.70	.01321	0.78	.01635	0.82	.03704

Whether there are or not significant differences between the groups were studied. Multiple variance analysis was done for the study. In the analysis, measurement factors such as type of adhesive, measurement and adhesive did not reveal statistically significant results ($P \geq 0.05$). Statistically significant differences were determined between other factors. Variance analysis results are given in Table 7, Page 51.

Table 7: Tests of between - subject effects in density values.

Source	Type III Sum of Squares	df	Mean Square	F	P
Wood	14.796	3	4.932	2739.230	.000
Layers	4.556	2	2.278	1265.126	.000
Adhesive	3.98E-005	1	3,98E-005	.022	.882
Measurment	.019	5	.004	2.105	.062
Adhesive * Measurment	.002	5	.000	.271	.929
Wood * Layers	2.219	6	.370	205.422	.000
Wood* Layers * Adhesive * Measurment	.770	121	.006	3.533	.000
Error	2.333	1296	.002		
Total	966.912	1440			
Corrected Total	24.695	1439			

Benferroni test, one of Post Hoc Tests, was applied to be able to see the differences between the groups. Analysis done on type of wood was statistically significant (F=2739.230, P=0001). Accordingly;

1. Density values of tested samples from oak wood and spruce wood have revealed significant differences. Density values of oak wood samples are higher than spruce wood density values.
2. Density values of tested samples from oak wood and tested samples from cypress wood have revealed significant differences. Density values of oak wood samples are higher than cypress wood density values.
3. Density values of tested samples from oak wood and chestnut wood have revealed significant differences. Density values of oak wood tested samples are higher than the density values of chestnut samples.
4. Density values of tested samples from cypress wood and spruce wood have revealed significant differences. Density values of sypress wood samples are higher than the density values of spruce wood samples.

5. Density values of tested samples from chestnut wood and spruce wood have revealed significant differences. Density values of Chestnut wood samples are higher than density values of spruce wood samples.

6. Density values of chestnut wood and cypress wood have revealed significant differences. Density values of chestnut wood samples are higher than the density values of cypress wood tested samples. Results are given in Table 8, Page 52.

Table 8: Density values test for wooden material types.

Kind of Wood	**Mean(g/cm^3)**	**Std. Error**	**Diferrent Groups**	**Bonferroni (P)**
Oak	0.94	.002	1. Oak- Spruce 2. Oak-Cypress	.0001 .0001
Spruce	0.67	.002	3. Oak-Chestnut	.0001
Cypress	0.78	.002	4. Cypress-Spruce 5. Chestnut-Spruce	.0001 .0001
Chestnut	0.86	.002	6. Chestnut-Cypress	.0001

For type of wood, the highest density values were obtained from oak wood samples and the lowest density values were obtained from spruce wood tested samples. Results are given in Figure 25, Page 52.

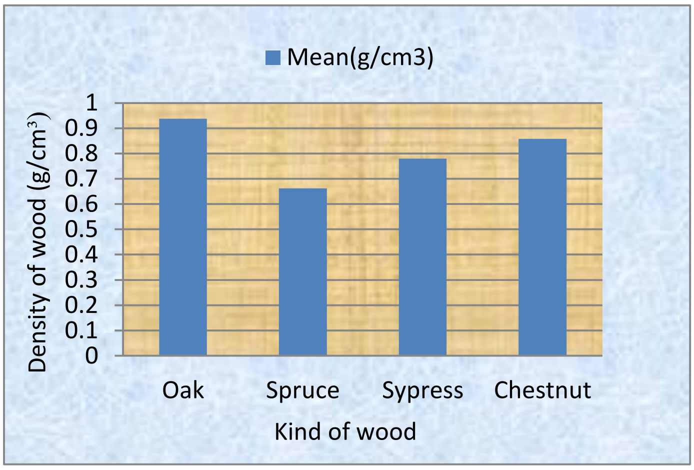


Figure 25: Avarage density values for wooden material types

Density values of wood-wood, wood*PC and wood*PMMA materials from which the tested samples were obtained in this study have shown statistically significance (F=1265.126, P=.0001). According to this;

1. There are significant differences between wood*wood tested samples and wood*PC samples. As a result, we might point out that PC material increases the density of samples.

2. There are significant differences between wood*wood and wood*PMMA tested samples. As a result, PMMA material increased the density of samples.

3. There are significant differences between wood*PMMA and wood*PC tested samples. As a result; density values of PC material is higher than PMMA material. Avarage values of the results are given in Table 9, Page 53.

Table 9: Average density values tests for materials which samples were taken from.

Layers	**Mean(g/cm^3)**	**Std. Error**	**Diferrent Groups**	**Bon. (P)**
Wood*wood	0.74	.002	1. Wood*wood-wood*PC	.0001
Wood*PC	0.87	.002	2. Wood*wood-wood*PMMA	.0001
Wood*PMMA	0.82	.002	3. wood*PMMA-wood*PC	.0001

The highest density values were obtained from wood*PC tested samples and the lowest density values were obtained from wood-wood tested samples for the wooden material samples taken from. Results are given in Figure 26, Page 53.

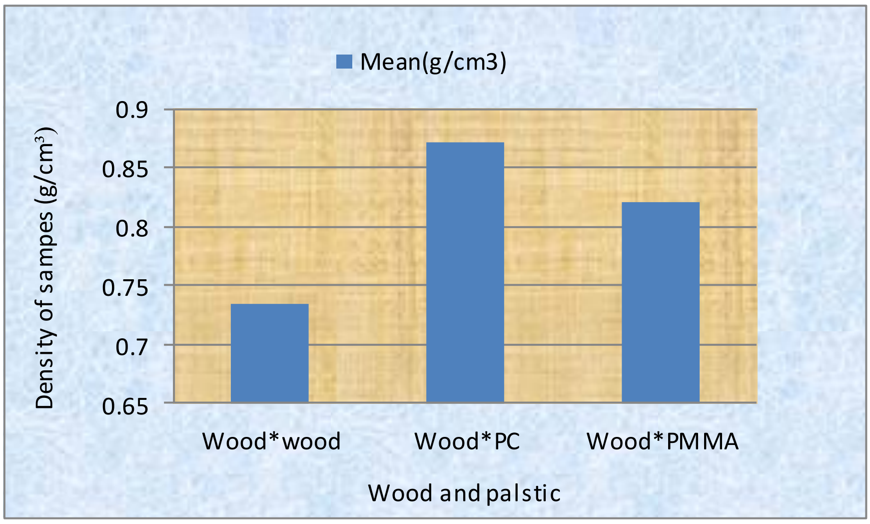


Figure 26: Avarage density values for material type taken from tested samples.

7.2. Results of Surface Roughness

At first, the differences between the Ra values of surface roughness of the tree species from which the measures were taken on the cross section to fibers were analyzed. Then differences between the surface roughness Ra measurements based on the measures which were parallel to fibers were analyzed. In the research as the number of tree species is more than two and each measurement was taken independent from each other, one-way analysis of variance was used as the statistical method (One-way ANOVA). Descriptive statistics about cross direction on surface roughness are given in Table 10, Page 54.

Table 10: Descriptive statistics about cross direction on surface roughness (Ra).

Kind of trees	N	Mean (µm)	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Cz Spruce	10	7.88	1.72284	.54481	6.6466	9.1114
Cz Oak	10	11.62	2.44812	.77416	9.8717	13.3743
T Chestnut	10	13.69	4.16449	1.31693	10.7069	16.6651
T Oak	10	10.59	4.18282	1.32272	7.6008	13.5852
T Cypress	10	6.42	2.06541	.65314	4.9375	7.8925
T Spruce	10	7.25	3.22181	1.01883	4.9413	9.5507
Total	60	9.57	3.97063	.51261	8.5479	10.5994

N: Samples number, Cz: Czech, T: Turk

First of all, statistically significant differences in tree species were obtained in this research in which differences between measures of surface roughness Ra of tree species on which measures were taken on cross section (F=8.298, P=0.0001). Table of 1-way ANOVA is given in Table 11, Page 54.

Table 11: One-way analysis of variance with reference to surface roughness of measures taken from cross section to the fibers

Kind of wood			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		404.172	5	80.834	8.298	.000
	Linear Term	Contrast	68.403	1	68.403	7.022	.011
		Deviation	335.769	4	83.942	8.617	.000
Within Groups			526.018	54	9.741		
Total			930.190	59			

To determine between which tree species are these differences Bonferroni, one of Post Hoc Tests, was applied. Results that were obtained are given in Table 12, Page 55. According to the results;

1. There is a statistically significant difference between the surface rougness of Cz spruce wood and T chestnut wood. In accordance with the difference Cz spruce wood surface roughness average Ra value has given better results than T chestnut wood.
2. There is a statistically significant difference between the surface roughness of Cz Oak wood and the surface roughness of T cypress wood. As a result, average Ra value of T Cypress surface roughness is less than Cz oak wood. In other words, samples from T Cypress wood have smoother surfaces than Cz oak wood.
3. There is a statistically significant difference between the surface roughness of Cz oak wood and the surface roughness of T Spruce wood. As a result of this difference, average Ra value of T spruce wood surface roughness has given better results than Cz oak wood.
4. There is a statistically significant difference between the surface roughness of T chestnut wood and the surface roughness of T spruce wood. As a result of this difference, average Ra value of T spruce wood surface roughness has given better results than T chestnut wood.
5. There is a statistically significant difference between the surface roughness of T chestnut wood and the surface roughness of T spruce wood. As a result, average Ra value of T spruce wood surface roughness has given better results compared to T chestnut wood.

Table 12: Surface roughness difference test of transverse measurement (Ra).

Kind of wood	**N**	**Mean (μm)**	**Std. Deviation**	**Different Groups**	**p**
Cz spruce	10	7.88	1.72284	1. Cz spruce with T-chestnut	.002
Cz-oak	10	11.62	2.44812	2. Cz oak with T-cypress	.007
T-chestnut	10	13.67	4.16449	3. Cz oak with T-spruce	.042
T-oak	10	10.59	4.18282	4. T chestnut with T-cypress	.0001
T-cypress	10	6.42	2.06541	5. T chestnut with T-spruce	.0001
T-spruce	10	7.25	3.22181		
Total	60	9.57	3.97063		

N: Samples number, Cz: Czech, T: Turk

Comparison results of Average (Ra) surface roughness values on the cross direction to wood fibers are given in a diagram in Figure 27, Page 56. Among all the samples, the smoothest surface has been obtained from T cypruce wood.

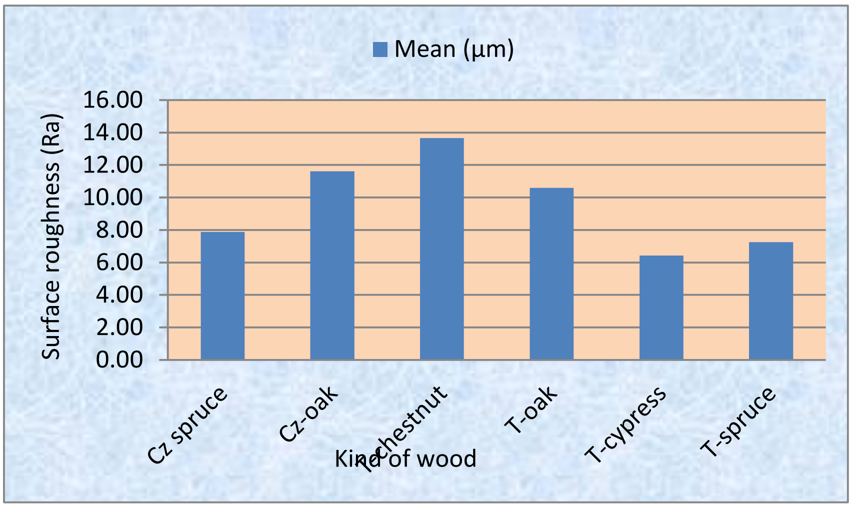


Figure 27: Graphical values in reference to surface roughness of measurements on the cross section.

In surface roughness, descriptive statistical results of the measurements parallel direction to the fibers are given in table 13, Page 56.

Table 13: Descriptive statistic about parallel direction to surface roughness (Ra)

Kind of trees	N	Mean (µm)	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Cz spruce	10	4.99	0.97772	.30918	4.2896	5.6884
Cz oak	10	5.93	5.59691	1.76990	1.9312	9.9388
T chestnut	10	6.64	3.60814	1.14099	4.0619	9.2241
T oak	10	5.21	2.82316	.89276	3.1864	7.2256
T cypress	10	4.73	3.16187	.99987	2.4691	6.9929
T spruce	10	5.93	2.24153	.70883	4.3295	7.5365
Total	60	5.57	3.29491	.42537	4.7217	6.4240

At the Second step, in which differences of surface roughness Ra measurements of tree species from which measurements were taken on the parallel direction to the fibers, statistically significant differences were not found (F=8.298, P=0,0001). Table of one-way ANOVA is given in Table 14, Page 57.

Table 14: One -way analysis of variance in terms of surface roughness of measures done on the parallel direction to the fibers.

Kind of wood			Sum ofSquares	df	Mean Square	F	P
Between Groups	(Combined)		25.903	5	5.181	.455	.808
	Linear Term	Contrast	.015	1	.015	.001	.971
		Deviation	25.887	4	6.472	.569	.687
Within Groups			614.629	54	11.382		
Total			640.531	59			

Bonferroni test, one of Post Hoc tests, was not applied because statistically significant differences did not found. Approximate values of measures done on the parallel direction to the fibers are given in Table 15, Page 57.

Table 15: Approximate values of measurement (Ra) had done on parallel direction to the fibers.

Kind of wood	N	Mean(Ra)	Std. Deviation	Std. Error
Cz spruce	10	4.99	.97772	.30918
Cz oak	10	5.94	5.59691	1.76990
Tchesnut	10	6.64	3.60814	1.14099
T oak	10	5.21	2.82316	.89276
T cypress	10	4.73	3.16187	.99987
T spruce	10	5.93	2.24153	.70883
Total	60	5.57	3.29491	.42537

When average values of surface roughness in measurements taken on parallel direction to the fibers, Table 4.8 is reviewed, T cypress sample from coniferous tree group gave the minimum rate 4.73 µm, T oak sample gave the maximum rate 6.93 µm. Results of surface roughness measurement on the parallel direction to fibers are given in the diagram in Figure 28, Page 58.

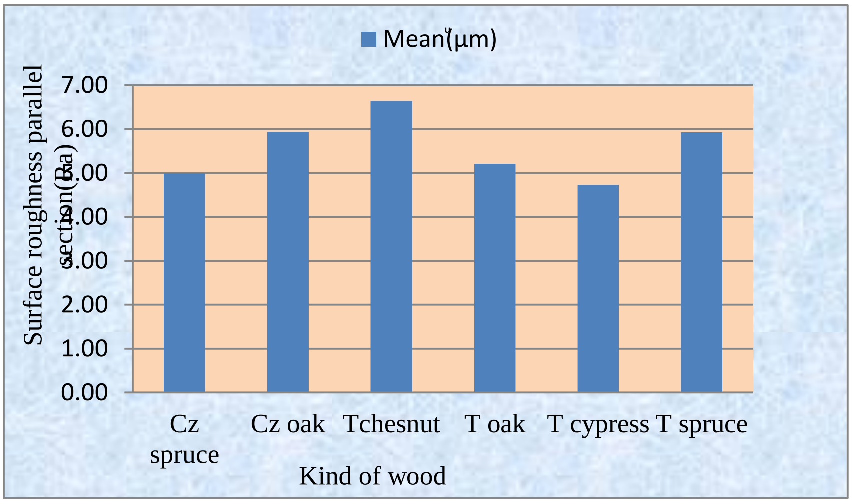


Figure 28: Graphical values in reference to surface roughness of measurements on the parallel section.

7.3. Results of Bonding Strength Test

Whether there are significant differences among the effects of kinds of tree (i.e. Cz oak, Cz spruce, T oak, T spruce, T cypress, T chestnut), kind of plastic surface material (i.e. PC and PMMA), kind of adhesive (i.e. Solvent, Polyurethane, Epoxy, and PVAc adhesives), and conditions after adhesion (i.e. room condition, hot chamber and the freezer chamber), on adhesion resistance or not, it was searched by using two-way analysis of variance. As a result, statistically significant differences were found out. In the analysis kind of tree as the independent variable and other variables as dependents were included in the tested samples. Descriptive statistics about adhesion resistance are given in Table 16, Page 59.

Table 16: Descriptive statistics about adhesion resistance.

Kind of tree	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Cz oak	4.15	.147	3.856	4.435
Cz spruce	3.64	.147	3.349	3.928
T oak	6.28	.120	6.044	6.516
T spruce	5.70	.120	5.462	5.934
T cypress	4.55	.120	4.315	4.787
T chestnut	5.38	.120	5.145	5.618
Kind of adhesive	**Mean**	**Std. Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Solvent	1.85	.208	1.443	2.261
PUR	3.33	.208	2.923	3.741
Epox	5.96	.079	5.807	6.116
PVAc	4.91	.079	4.757	5.066
Number of layers	**Mean**	**Std. Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Wood*wood	7.39	.090	7.215	7.569
Wood*PC	3.96	.090	3.786	4.140
Wood *PMMA	3.87	.090	3.711	4.065
Conditions after adhesion	**Mean**	**Std. Error**	**95% Confidence Interval**	
			Lower Bound	**Upper Bound**
Room temperature	4.85	.074	4.710	4.999
High temperature	5.29	.104	5.086	5.495
The freezer chamber	5.33	.104	5.121	5.530

Among the effects of kind of tree (i.e. Cz oak, Cz spruce, T oak, T spruce, T cypress and T chestnut), plastic surface material (i.e. PC and PMMA), kind of adhesive (i.e. Solvent adhesive, PUR adhesive, Epoxy adhesive and PVAc adhesive) and conditions after adhesion, on adhesion resistance differences, as kind of tree and kind of adhesive interaction was not significant, all the other effects were found statistically significant. If the significance level is assumed 10 %, kind of tree and adhesive interaction can be admitted as significant. Two-way analysis on variance is given in Table 17, Page 60.

Table 17: Experiment on the effects of kind of tree, plastic surface material, kind of adhesive and conditions after adhesion on adhesion resistance differences.

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**P**
Kind of wood	327.523	5	65.505	25.151	0.000
Kind of adhesive	692.932	3	230.977	88.685	0.000
Samples	2757.473	2	1378.737	529.372	0.000
Conditions after adhesion	41.575	2	20.788	7.982	0.000
Kind of wood * Kind of adhesive	33.979	7	4.854	1.864	0.072
Kind of wood * Samples	440.478	10	44.048	16.912	0.000
Kind of wood * Conditions after adhesion	131.747	6	21.958	8.431	0.000
Kind of wood * Kind of adhesive * Samples	1166.868	20	58.343	22.401	0.000
Kind of wood * Kind of adhesive * Conditions after adhesion	147.160	8	18.395	7.063	0.000
Kind of wood * Kind of adhesive * Samples * Conditions after adhesion	601.671	32	18.802	7.219	0.000
Error	2250.268	864	2.604		
Total	33613.965	960			
Corrected Total	8829.325	959			

One of the Post-Hoc tests Bonferroni was applied to see between which groups were the differences. Especially, it was studied whether adhesion resistance varied in terms of kinds of tree and significant differences were found out. (F=57.497, P=.0001). According to that:

1. Adhesion resistance of Cz oak and T oak differ from each other. T oak tree affected adhesion resistance in a more positive way when compared to Cz oak tree.
2. Adhesion resistance of Cz oak and T spruce differ from each other. Accordingly, it was determined that T spruce tree affected the adhesion resistance more positively than Cz oak tree.
3. Adhesion resistance of Cz oak and T chestnut differ from each other. According to this, it was found that T chestnut tree affected adhesion resistance more positively than Cz oak tree.
4. Adhesion resistance of Cz spruce and T oak differ from each other. According to this it was found that T oak tree affected adhesion resistance more positively than Cz spruce tree.

5. Adhesion resistance of Cz spruce and T spruce differ from each other. According to this it was found that T spruce tree affected adhesion resistance more positively than Cz spruce tree.

6. Adhesion resistance of Cz spruce and T cypress trees differ from each other. According to this it was found that T cypress tree affected adhesion resistance more positively than Cz spruce tree.

7. Adhesion resistance of Cz spruce and T chestnut trees differ from each other. According to this it was found that T chestnut tree affected adhesion resistance more positively than Cz spruce tree.

8. Adhesion resistance of T oak and T spruce trees differ from each other. According to this it was found that T oak tree affected adhesion resistance more positively than Cz spruce tree.

9. Adhesion resistance of T oak and T cypress trees differ from each other. According to this it was found that T oak tree affected adhesion resistance more positively than Cz cypress tree.

10. Adhesion resistance of T oak and T chestnut trees differ from each other. According to this it was found that T oak tree affected adhesion resistance more positively than T chestnut tree.

11. Adhesion resistance of T spruce and T cypress trees differ from each other. According to this it was found that T spruce tree affected adhesion resistance more positively than Cz cypress tree.

12. According to this it was found that T chestnut tree affected adhesion resistance more positively than T cypress tree. Results are given in Table 18, Page 61.

Table 18: Difference test on adhesion resistance for different kinds of trees.

Kind of tree	**Mean (N/mm^2)**	**Std. Error**	**Different groups**	**Bon. (P)**	**Different groups**	**Bon. (P)**
Cz oak	4.15	.147	1.Cz oak - T oak	.0001	7. Cz spruce - T chestnut	.0001
Cz spruce	3.64	.147	2. Cz oak - T spruce	.0001	8. T oak - T spruce	.0100
T oak	6.28	.120	3.Cz oak - T chestnut	.0001	9. T oak - T cypress	.0001
T spruce	5.70	.120	4.Cz spruce -T oak	.0001	10. T oak - T chestnut	.0001
T cypress	4.55	.120	5. Cz spruce - T spruce	.0001	11. T spruce - T cypress	.0001
T chestnut	5.38	.120	6.Cz spruce - T cypress	.0001	12.T cypress - T oak	.0001

Cz: Czech, T: Turk, Bon: Bonferroni

Bonding strength test was applied on the samples which were kept in room, hot and the freezer temperature for 3 weeks. Results are compared with regard to type of wooden material. Comparison results are given in a diagram in Figure 29, Page 62.

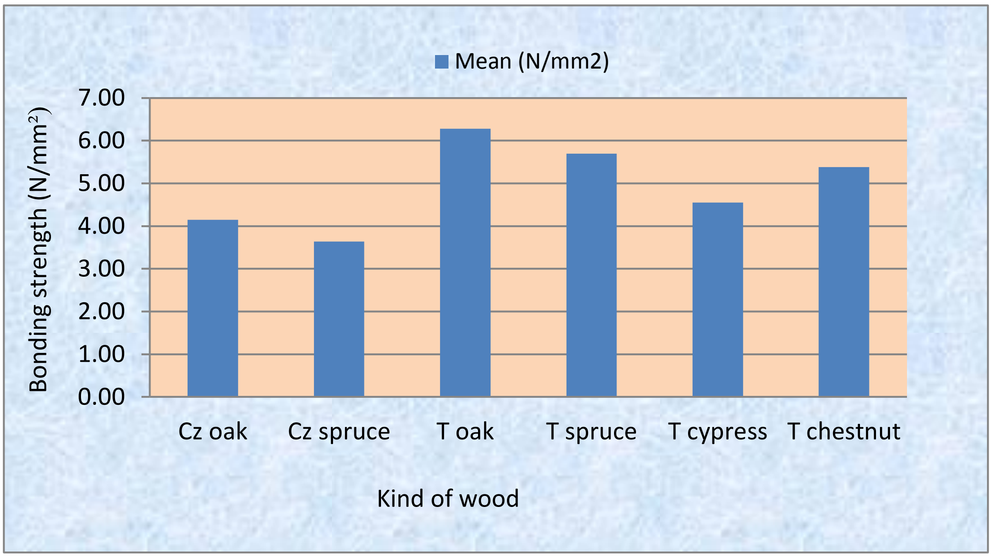


Figure 29: According to the type of wood material bonding strength mean values.

After the difference search according to kind of tree, it was studied whether adhesion resistance varies according to kind of adhesive and significant differences were found. (F=146.743, P=.0001). According to the study;

1. Adhesion resistance of solvent and polyurethane (PUR) adhesives differ from each other. Accordingly, on wood*wood samples adhesion resistance of PUR adhesive was more positive than solvent adhesive.

2. Adhesion resistance of solvent and epoxy adhesives differs from each other. Accordingly, adhesion resistance of epoxy adhesive was more positive than solvent adhesive.

3. Adhesion resistance of solvent and PVAc adhesives differ from each other. Accordingly, adhesion resistance of PVAc adhesive was more positive than solvent adhesive.

4. Adhesion resistances of PUR and epoxy adhesives differ from each other. Accordingly, adhesion resistance of epoxy adhesive was more positive than PUR adhesive.

5. Adhesion resistance of PUR and PVAc adhesives differ from each other. Accordingly, adhesion resistance of PVAc adhesive was more positive than PUR adhesive.

6. Adhesion resistance of epoxy and PVAc adhesives differ from each other. Accordingly, adhesion resistance of epoxy adhesive was more positive than PVAc adhesive. Results obtained from the experiment are shown in Table 19, Page 63.

Table 19: Difference test of adhesion resistance for adhesive kinds.

Kind of adhesive	**Mean (N/mm^2)**	**Std. Error**	**Different groups**	**Bon. (P)**	**Different groups**	**Bon. (P)**
Solvent	1.85	.208	1. Solvent - PUR	.0001	5. PUR - PVAc	.0001
PUR	3.33	.208	2. Solvent - Epoxy	.0001	6. Epoxy - PVAc	.0001
Epoxy	5.96	.079	3. Solvent- PVAc	.0001		
PVAc	4.91	.079	4. PUR - Epoxy	.0001		

Bon: Bonferroni

For the samples which were kept in room conditions, hot and the freezer temperature for 3 weeks and tested for bonding strength with regard to type of adhesive, results are given in a diagram in Figure 30, Page 63.

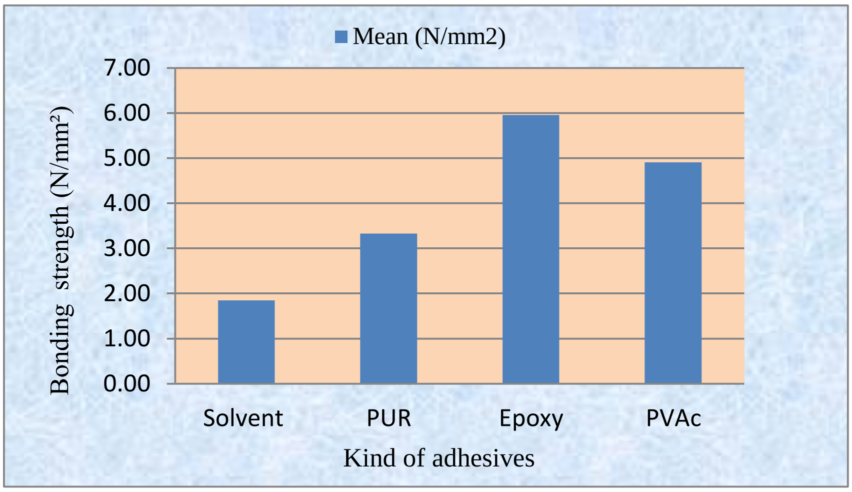


Figure 30: Bonding strenth average values for type of adhesive.

It was analyzed whether adhesion resistance vary according to the kind of material that samples were taken and significant differences were found out. (F = 492.294, P = .0001). According to this;

1. Adhesion resistance of wood*wood tested samples and wood*PC samples differ. Accordingly, wood*wood tested samples affected adhesion resistance more positively than wood*PC samples.
2. Adhesion resistance of wood*wood tested samples and wood*PMMA tested samples differ. Accordingly, wood*wood tested samples affected adhesion resistance more positively than wood*PMMA tested samples. Results obtained from the experiment are shown in Table 20, Page 64.

Table 20: Experiment on adhesion resistance according to the kind of material that tested samples were taken.

Number of layers	**Mean(N/mm^2)**	**Std. Error**	**Different groups**	**Bon. (P)**
Wood*wood	7.39	.090	1.Wood*wood – wood*PC	.0001
Wood*PC	3.96	.090	2.Wood*wood – wood*PMMA	.0001
Wood*PMMA	3.89	.090		

PC: polycarbonate, PMMA: Polymetilmetacralate

For the tested samples which were kept in room, hot and the freezer temperature for three weeks and tested for bonding strength with respect to materials samples taken from, bonding strength results are given in Figure 31, Page 65. In these three tested conditions, the best result was obtained from the tested samples bonded with epoxy adhesive.

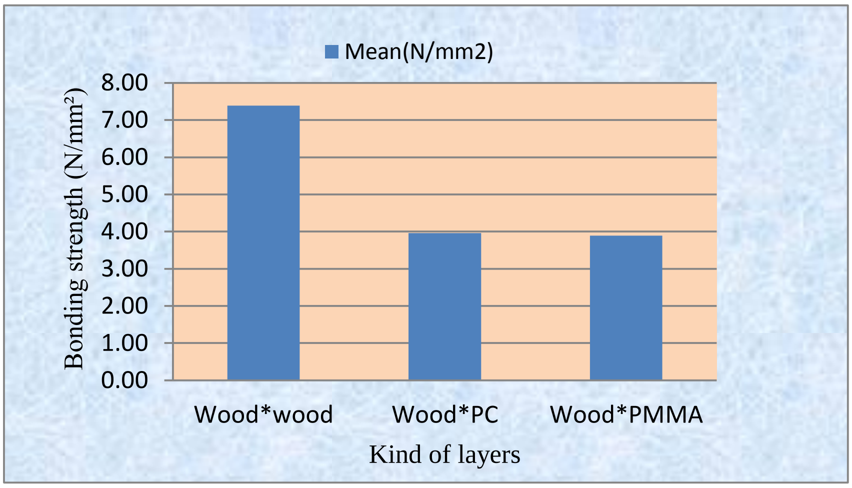


Figure 31: Bonding strength values for the materials samples taken from.

It was analyzed whether adhesion resistance varied according to the waiting condition after adhesion and significant differences were found out. ($F = 9.504$, $P = .0001$). According to this;

1. Adhesion resistance of the tested samples which were kept in the room temperature and the ones kept in hot tempreature differ from each other. The tested samples kept in the hot temperature affected adhesion resistance more positively than the tested samples kept in the room temperature.

2. Adhesion resistance of the tested samples which were kept in the room temperature and the ones kept in the freezer chamber differ from each other. The tested samples kept in the the freezer chamber affected adhesion resistance more positively than the tested samples kept in the room temperature. Results derived from the study are shown in Table 21, Page 65.

Table 21: Difference test on adhesion resistance according to the conditions of the tested samples after adhesion.

Conditions after adhesion	**Mean (N/mm^2)**	**Std. Error**	**Different groups**	**Bon. (P)**
Room temperature	4.85	.074	1. Room temperature - Hot temperature	.0002
High temperature	5.29	.104	2. Room temperature - The freezer chamber	.0001
The freezer chamber	5.33	.104		

The tested samples were kept in room temperature, hot pemperature and the freezer for 3 weeks and tested for bonding strength. Bonding strength results for keeping conditions are given Figure 32, Page 66. As a result, tested samples which were kept in high temperatere test chamber and the freezer have given better results compared to the ones kept in room temperature.

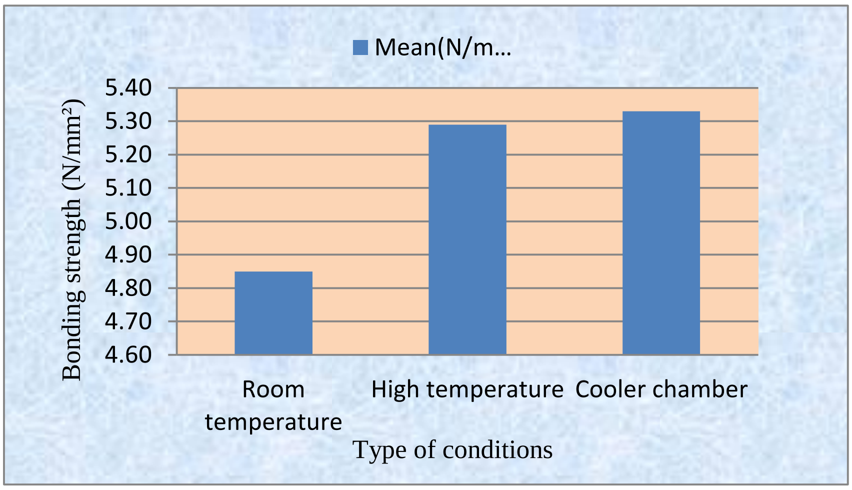


Figure 32: Avarage results of bonding strength for keeping conditions of samples.

7.3.1. Paired comparison of adhesion resistance values

7.3.1.1. Paired comparison for kinds of tree and adhesive

Interaction of kind of tree and kinds of adhesive was tested and 5% interaction was not accepted as significant (P≥05). However, if significance level is accepted as 10%, it is found that this interaction is significant (F=1.864, P=0.072). Yet, differences between groups were recognized. To be able to see these differences, by handling type of tree and type of adhesive together they were transformed in to one variable, and new set of date was formed. Data was tested with one-way ANOVA and in multiple comparisons Bonforrini test was applied. In one-way analysis of variance, effects of tree kind and adhesive kind on adhesion resistance were found statistically important (F=12.727 P=.0001). But in the samples of Cz oak-PC, PMMA and Cz spruce-PC, PMMA adhesion resistance value could not be obtained. Thus, in the adhesion of other tested samples these two adhesive types were not used. First of all, it was analyzed whether adhesion resistance differs related to kind of tree and kind of adhesive and important differences were found. According to this;

1. Adhesion resistance of Cz oak tested samples bonded with solvent adhesive and Cz oak tested samples bonded with epoxy adhesive differ from each other. Cz oak tested samples bonded with epoxy adhesive affected bonding more positively than the Cz oak tested samples bonded with solvent adhesive.

2. Cz oak tested samples bonded with solvent adhesive differ from the Cz oak tested samples bonded with PVAc in adhesion resistance. For this, Cz oak tested samples bonded with PVAc adhesive affected bonding more positively than Cz oak tested samples bonded with solvent adhesive.

3. Cz oak tested samples bonded with PUR adhesive differ from the Cz oak tested samples bonded with epoxy in adhesion resistance. For this, Cz oak tested samples bonded with epoxy adhesive affected bonding more positively than Cz oak samples bonded with solvent adhesive.

4. Cz spruce tested samples bonded with solvent adhesive differ from the Cz spruce tested samples bonded with epoxy in adhesion resistance. For this, Cz oak samples bonded with epoxy adhesive affected bonding more positively than Cz oak tested samples bonded with solvent adhesive.

5. Cz spruce tested samples bonded with solvent adhesive differ from the Cz spruce tested samples bonded with PVAc in adhesion resistance. For this, Cz spruce samples bonded with PVAc adhesive affected bonding more positively than Cz spruce tested samples bonded with solvent adhesive. Results obtained are given in Table 22, Page 68.

Table 22: Test on adhesion resistance in accordance with wood and adhesive kinds.

Type of tree	N	Type of adh.	Mean (N/mm^2)	Std. Deviation	Std. Error	Different groups	Bon. (P)
Cz oak	30	Solvent	2.14	1.07021	.19539	1. Cz oak, solvent - Cz oak, epoxy	.0001
	30	PUR	3.21	4.79516	.87547	2. Cz oak, solvent- Cz oak, PVAc	.0048
	30	Epoxy	6.54	5.02298	.91707	3. Cz oak, PUR - Cz oak, epoxy	.0001
	30	PVAc	4.70	3.14419	.57405	4. Cz spruce, solvent - Cz spruce, epoxy	.0001
Cz spruce	30	Solvent	1.57	.92951	.16970	5. Cz spruce, solvent - Cz spruce, PVAc	.0009
	30	PUR	3.46	5.01349	.91533		
	30	Epoxy	5.09	2.70413	.49370		
	30	PVAc	4.44	1.78794	.32643		
T oak	90	Epoxy	6.72	3.32527	.35051		
	90	PVAc	5.84	2.50811	.26438		
T spru	90	Epoxy	6.30	1.60255	.16892		
	90	PVAc	5.09	1.77550	.18715		
T cypr	90	Epoxy	4.90	2.54481	.26825		
	90	PVAc	4.20	2.48362	.26180		
T ches	90	Epoxy	6.01	3.11590	.32844		
	90	PVAc	4.75	2.42748	.25588		

According to bonding strength test results, a comparison was made between wooden material surface and type of adhesive. Comparison results are presented in Figure 33, Page 69. The best result has been obtained from the tested samples from T oak wood which were bonded with epoxy adhesive.

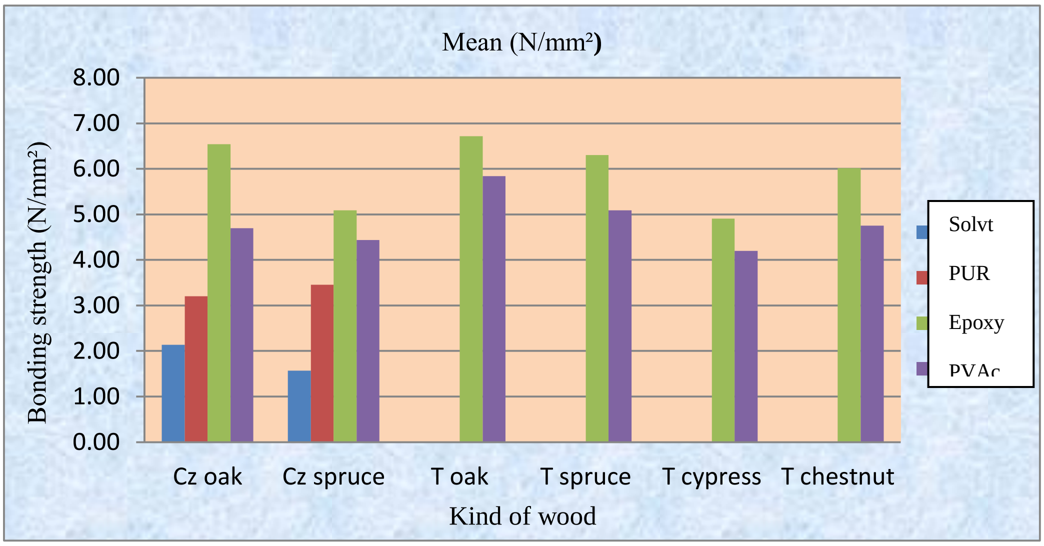


Figure 33: Average bonding strength values for wooden materila and type of adhesive.

7.3. 1.2. Paired Comparison In Accordance With Kind Of Tree and Materials From Which Samples Were Taken

Whether the interaction between kind of tree and materials from which tested samples were taken, was analyzed and 5% interaction level was found significant (F=12.727 P=.0001). Yet, differences between groups could not be determined. To be able to see these differences, kind of tree and materials which tested samples were taken from evaluated and transformed into one variable data set was re-formed. Data was tested with one-way ANOVA and in multiple comparisons Bonforrini test was applied. In one way analysis on variance, effects on adhesion resistance according to tree kinds and materials from which samples were taken were defines as statistically significant (F=16.912, P=0001). According to this that;

1. Wood*wood tested samples of Cz oak tree and wood*PC tested samples of Cz oak tree differ from each other in adhesion resistance. Wood*wood tested samples of Cz oak tree affected adhesion resistance more positively than wood*PC tested samples of Cz oak tree.

2. Wood*wood tested samples of Cz oak tree and wood*PMMA tested samples of Cz oak tree are different from each other. According to that, wood*wood tested samples of Cz oak tree affected adhesion resistance more positively than wood*PMMA tested samples of Cz oak tree.

3. Wood*wood tested samples of Cz spruce tree and wood*PC samples of Cz spruce tree are different from each other. According to that, wood*wood tested samples of Cz spruce tree affected adhesion resistance more positively than wood*PC tested samples of Cz spruce tree.

4. Wood*wood tested samples of Cz spruce tree and wood*PMMA tested samples of Cz spruce tree are different from each other. According to that, wood*wood tested samples of Cz spruce tree affected adhesion resistance more positively than wood*PMMA tested samples of Cz spruce tree.

5. Wood*wood tested samples of T oak tree and wood*PC samples of T oak tree are different from each other. According to that, wood*wood tested samples of T oak tree affected adhesion resistance more positively than wood*PC tested samples of T oak tree.

6. Wood*wood tested samples of T oak tree and wood*PMMA tested samples of T oak tree are different from each other. According to that, wood*wood tested samples of T oak tree affected adhesion resistance more positively than wood*PMMA tested samples of T oak tree.

7. Wood*wood tested samples of T spruce tree and wood*PC tested samples of T spruce tree are different from each other. According to that, wood*wood tested samples of T spruce tree affected adhesion resistance more positively than wood*PC samples of T spruce tree.

8. Wood*wood tested samples of T spruce tree and wood*PMMA tested samples of T spruce tree are different from each other. According to that, wood*wood samples of T spruce tree affected adhesion resistance more positively than wood*PMMA tested samples of T spruce tree.

9. Wood*wood tested samples of T cypress tree and wood*PC tested samples of T cypress tree are different from each other. According to that, wood*wood tested samples of T oak tree affected adhesion resistance more positively than wood*PC tested samples of T cypress tree.

10. Wood*wood samples of T cypress tree and wood*PMMA tested samples of T cypress tree are different from each other. According to that, wood*wood tested samples of T cypress tree affected adhesion resistance more positively than wood-PMMA samples of T cypress tree.

11. Wood*wood tested samples of T chestnut tree and wood*PC samples of T chestnut tree are different from each other. According to that, wood*wood tested samples of T chestnut tree affected adhesion resistance more positively than wood*PC tested samples of T chestnut tree.

12. Wood*wood tested samples of T chestnut tree and wood*PMMA samples of T chestnut tree are different from each other. According to that, wood*wood tested samples of T chestnut tree affected adhesion resistance more positively than wood*PMMA tested samples of T chestnut tree. Results are given in Table 23, Page 71.

Table 23: Adhesion resistance differences according to kind of tree and materials from which samples were taken.

Kind of tree	**layer**	**N**	**Mean (N/mm^2)**	**Std. Deviation**	**Std. Error**	**Different groups**	**Bon. (P)**
Cz oak	Wood*wood	40	8.46	4.27489	.67592	1. Cz oak, wood*wood - Cz oak, wood*PC	.0001
	Wood*PC	40	2.08	1.80692	.28570	2. Cz oak, wood*wood - Cz oak, PMMA	.0001
	Wood*PMMA	40	1.90	1.53039	.24198	3. Cz spr., wood-wood – Cz spr.,wood*PC	.0001
Cz spruce	Wood*wood	40	6.14	3.29926	.52166	4. Cz spr., wood*wood - Cz spr., PMMA	.0001
	Wood*PC	40	2.94	2.85315	.45112	5. T oak, wood* wood - T oak, wood*PC	.0001
	Wood*PMMA	40	1.83	1.81792	.28744	6. T oak, wood-wood -T oak, PMMA	.0001
T oak	Wood*wood	60	8.99	3.01127	.38875	7. T spr., wood*wood - T spr., wood*PC	.0001
	Wood*PC	60	4.93	1.82848	.23606	8. T spr., wood*wood - T cpr.,Wood*PMMA	.007
	Wood*PMMA	60	4.92	1.76946	.22844	9. T cyp. wood*wood - T cyp., wood*PC	.035
T spruce	Wood*wood	60	6.98	1.96266	.25338	10. T cyp., wood*wood-T cyp.,wood*PMMA	.015
	Wood*PC	60	4.91	1.33430	.17226	11. T chest. wood*wood-T chest.,wood*PC	.0001
	Wood*PMMA	60	5.19	1.24729	.16102	12. T chest., wood*wood-T chest., wood*PMMA	.0001
T cypress	Wood*wood	60	6.70	2.64331	.34125		
	Wood*PC	60	3.71	1.72053	.22212		
	Wood*PMMA	60	3.24	1.53831	.19859		
T chest.	Wood*wood	60	7.02	3.71661	.47981		
	Wood*PC	60	4.23	1.74732	.22558		
	Wood*PMMA	60	4.89	1.89015	.24402		

In this section in which wood to wood and wood to plastic bonding are studied, bonding strength for the bonding of wood to wood and wood to plastic, there has been 80% loss of bonding strength in Cz wood and 50% in T wood. Results are given in a diagram in Figure 34, Page 72.

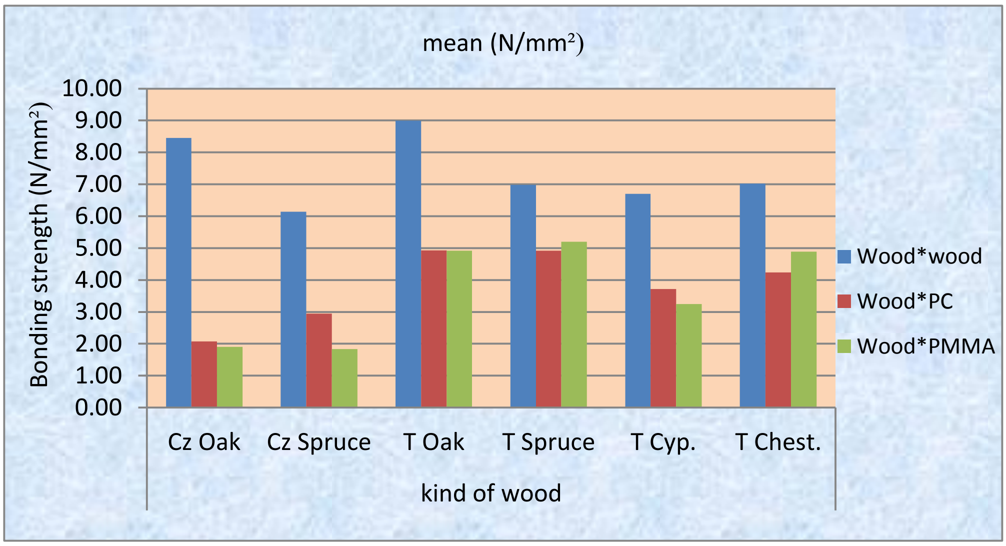


Figure 34: Average values of bonding strength for type of wood and the materials samples were taken from.

7.3.1.3. Paired Comparison According to Kind of Tree and Conditions After Adhesion

It was analyzed whether interaction of kind of tree and conditions after adhesion and 5% interaction level was determined to be significant (F= 8,431 P=.0001). However, variations between groups could not be determined. To be able to see these differences kind of tree and conditions after adhesion were evaluated and they were transformed into one variation. Thus, data set was re-formed. Data was tested with one-way ANOVA and Bonforrini, one of multiple comparison tests, was used. In one-way analysis of variance which was applied, effects of type of tree and conditions after adhesion on adhesion resistance was found statistically significant (F=34.601, P= .0001). In reference to that experiment;

1. Cz oak wood tested samples which were kept in room temperature after adhesion differ from T oak samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature

affected adhesion positively compared to Cz oak wood tested samples which were kept in room temperature.

2. Cz spruce wood tested samples which were kept in room temperature after adhesion differ from T oak tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature.

3. T oak wood tested samples which were kept in room temperature after adhesion differ from T oak tested samples which were kept in high temperature test chamber in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T oak wood samples which were kept in high temperature test chamber.

4. T oak wood tested samples which were kept in room temperature after adhesion differ from T spruce tested samples which were kept in high temperature test chamber in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T spruce wood tested samples which were kept in high temperature test chamber.

5. T oak wood tested samples which were kept in room temperature after adhesion differ from T spruce samples which were kept in the freezer cabinets in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T spruce wood tested samples which were kept in the freezer cabinet.

6. T oak wood tested samples which were kept in room temperature after adhesion differ from T cypress tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T cypress wood tested samples which were kept in the room temparature.

7. T oak wood tested samples which were kept in room temperature after adhesion differ from T cypress tested samples which were kept in high temperature test chamber in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T cypress wood samples which were kept in high temperature test chamber.

8. T oak wood tested samples which were kept in room temperature after adhesion differ from T cypress tested samples which were kept in the freezer cabinet in adhesion resistance. Accordingly, T oak wood tested samples kept in the room temperature affected adhesion positively compared to T cypress wood tested samples which were kept in the freezer cabinets.

9. T oak wood tested samples which were kept in room temperature after adhesion differ from T chestnut tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood samples kept in the room temperature affected adhesion positively compared to T chestnut wood samples which were kept in room temperature.

10. T oak wood tested samples which were kept in room temperature after adhesion differ from T chestnut tested samples which were kept in the freezer high temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in room temperature affected adhesion positively compared to T chestnut wood tested samples which were kept in the freezer cabinets.

11. T oak wood tested samples which were kept in high temperature test chamber after adhesion differ from T spruce tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood samples kept in controlled test chamber affected adhesion positively compared to T spruce wood tested samples which were kept in room temperature.

12. T oak wood tested samples which were kept in the freezer cabinet after adhesion differ from Cz oak tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in the the freezer cabinet affected adhesion positively compared to Cz oak wood samples which were kept in room temperature.

13. T oak wood tested samples which were kept in the freezer cabinet after adhesion differ from Cz spruce tested samples which were kept in room temperature in adhesion resistance. Accordingly, T oak wood tested samples kept in room temperature affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature.

14. Cz spruce wood tested samples which were kept in room temperature after adhesion differ from Cz oak tested samples which were kept in room temperature in adhesion resistance. Accordingly, Cz oak wood tested samples kept in room

temperature affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature, as well.

15. T spruce wood tested samples which were kept in room temperature after adhesion differ from Cz spruce samples which were kept in room temperature in adhesion resistance. Accordingly, T spruce wood tested samples kept in temperature affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature.

16. T spruce wood tested samples which were kept in high temperature test chamber after adhesion differ from Cz spruce tested samples which were kept in room temperature in adhesion resistance. Accordingly, T spruce wood tested samples kept in room temperature affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature.

17. T chestnut wood tested samples which were kept in the freezer cabinet after adhesion differ from Cz spruce tested samples which were kept in room temperature in adhesion resistance. Accordingly, T chestnut wood tested samples kept in the the freezer cabinet affected adhesion positively compared to Cz spruce wood tested samples which were kept in room temperature. Results obtained from the study are given in Table 24, Page 76.

Table 24: Test on adhesion resistance between groups according to kind of tree and after adhesion conditions.

Kind of Tree	Conditions	N	Mean (N/mm^2)	Std. Deviation	Std. Error	Different groups	Bon. (P)
Cz oak	Room tem	120	4.15	4.14762	.37862	1. Cz oak, room temp.-T oak, room temp. 2. Cz spruce, room temp -T oak, room temp	.0001 .0001
Cz spruce	Room tem	120	3.64	3.26823	.29835	3. T oak, room temp -T spruce, high temp. 4. T oak, room temp -T oak, high temp	.041 .042
T oak	Room tem	60	7.41	3.77079	.48681	5. T oak, room temp -T spruce, the freezer	.041
	High tem.	60	5.54	2.41906	.31230	6. T oak, room temp -T cypress, room temp.	.0001
	The freezer	60	5.89	2.16649	.27969	7. T oak, room temp -T cypress, high temp.	.0001
T spruce	Room tem	60	5.99	1.67218	.21588	8. T oak, room temp -T cypress, the freezer	.0001
	High tem	60	5.55	1.65460	.21361	9. T oak, room temp -T chestnut, room temp.	.0001
	The freezer	60	5.54	2.01956	.26072	10. T oak, room temp -T cypress, the freezer	.0001
T cypress	Room tem	60	4.95	2.69158	.34748	11. T oak, high temp.-Cz Spruce, room temp.	.003
	High tem	60	4.17	2.09341	.27026	12. T oak, the freezer-Cz oak , room temp.	.013
	The freezer	60	4.53	2.74234	.35403	13. T oak, the freezer-Cz spruce, room temp.	.0001
T chestnut	Room tem	60	4.91	2.20308	.28442	14. T spruce, room temp -Cz oak, room temp.	.005
	High tem	60	5.90	2.54035	.32796	15. T spruce, room temp -Cz spruce, room temp.	.0001
	The freezer	60	5.34	3.59853	.46457	16. T Spruce, high temp.-C spruce, room temp 17. T Chestnut, high temp.-C spruce, room temp.	.003 .013

Bonding test results have been evaluated diagrammatically for type of wood and keeping conditions after bonding. Results are given in Figure 35, Page 77. The best results for bonding strength have been obtained from T oak wood which was kept in room temperature.

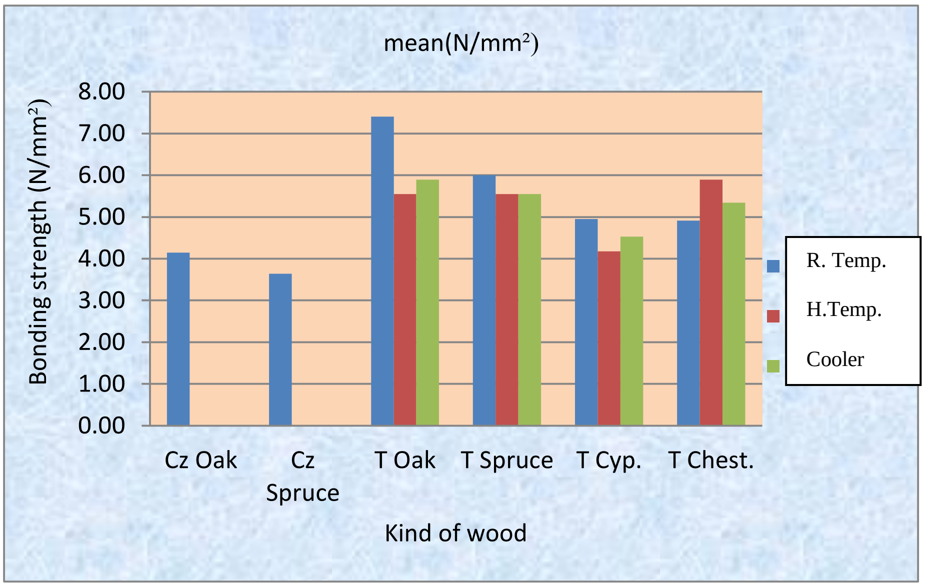


Figure 35: Average bonding test values for type of wood and keeping conditions after bonding.

7.3.1.4. Triple Comparisons For Kind of Tree and Materials Which Were the Samples Taken From

It was analyzed whether interaction was significant in reference to kind of tree, kind of adhesive and materials from which tested samples were derived, and 5 % interaction was determined to be significant (F= 22,401 P=.0001). Yet, variations between groups could not be determined. To be able to see the variations by evaluating kind of tree, kind of adhesive and materials together and they were turned into one variation, and data set was re-prepared. Data was tested with one-way ANOVA and Bonforrini, one of multiple comparison tests, was applied. In one-way analysis of variance which was applied, effects of kind of tree, kind of adhesive and materials these samples were obtained on adhesion resistance were defined as statistically significant (F=8.486 P= .0001). With this information;

1. Wood*wood tested samples from Cz oak which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*wood tested samples from Cz oak tree that were bonded with solvent adhesive.

2. Wood*wood tested samples from Cz oak which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*wood tested samples from Cz oak tree that were bonded with solvent adhesive.

3. Wood*wood tested samples from Cz oak which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*wood tested samples from Cz oak tree that were bonded with solvent adhesive.

4. Wood*wood tested samples from Cz oak which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz oak bonded with Epoxy adhesive in adhesion resistance. Consequently, wood*wood tested sample from Czoak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*wood tested samples from Cz oak tree that were bonded with PVAc adhesive.

5. Wood*PC tested samples from Cz oak and PC materials which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with solvent adhesive.

6. Wood*PC tested samples from Cz oak and PC material which were bonded with contact adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood sample from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with solvent adhesive.

7. Wood*PC tested samples from Cz oak which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree that were bonded with solvent adhesive.

8. Wood*PC tested samples from Cz oak and PC material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with PUR adhesive.

9. Wood*PC tested samples from Cz oak and PC which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with PUR adhesive.

10. Wood*PC tested samples from Cz oak and PC material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC samples from Cz oak and PC material that were bonded with PUR adhesive.

11. Wood*PC tested samples from Czoak and PC material which were bonded with PUR adhesive differ from wood*PC tested samples from Cz oak and PC material bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz oak wood and PC material that were bonded with epoxy adhesive affected bonding positively compared to wood*PC samples from Cz oak tree and PC material that were bonded with PUR adhesive.

12. Wood*PC tested samples from Cz oak and PC which were bonded with PUR adhesive differ from wood*PMMA tested samples from Cz oak and PMMA material bonded with PVAc adhesive in adhesion resistance. Consequently, wood*PMMA tested samples from Cz oak wood and PMMA that were bonded with PVAc adhesive affected bonding positively compared to wood*PC samples from Cz oak tree and PC that were bonded with PUR adhesive.

13. Wood*PC tested samples from Cz oak and PC material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to

wood*PC samples from Czoak tree and PC material that were bonded with epoxy adhesive.

14. Wood*PC tested samples from Cz oak which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with epoxy adhesive.

15. Wood*PC tested samples from Cz oak which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with epoxy adhesive.

16. Wood*PC tested samples from Cz oak PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz zoak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with PVAc adhesive.

17. Wood*PC tested samples from Cz oak and PC which were bonded with PVAc adhesive differ from wood*wood samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC material that were bonded with PVAc adhesive.

18. Wood*PC tested samples from Cz oak and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz oak tree and PC that were bonded with PVAc adhesive.

19. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PUR adhesive affected bonding

positively compared to wood*PMMA samples from Cz oak tree and PMMA that were bonded with solvent adhesive.

20. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA samples from Cz oak tree and PMMA material that were bonded with solvent adhesive.

21. Wood*PMMA tested samples from Cz oak which were bonded with solvent adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree that were bonded with solvent adhesive.

22. Wood*PMMA tested samples from Cz oak and PMMA which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree and PMMA that were bonded with PUR adhesive.

23. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree and PMMA material that were bonded with PUR adhesive.

24. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood-PMMA samples from Cz oak tree that were bonded with PUR adhesive.

25. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PUR adhesive differ from wood*PC samples from Cz oak and PC material

bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz oak wood and PC material that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree that were bonded with PUR adhesive.

26. Wood*PMMA tested samples from Cz oak which were bonded with PUR adhesive differ from wood*PMMA tested samples from Cz oak and PMMA material bonded with PVAc adhesive in adhesion resistance. Consequently, wood*PMMA tested sample from Cz oak wood and PMMA material that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree and PMMA material that were bonded with PUR adhesive.

27. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PUR adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree and PMMA materials that were bonded with epoxy adhesive.

28. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree and PMMA that were bonded with Epoxy adhesive.

29. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested sample from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree that were bonded with epoxy adhesive.

30. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz oak bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PUR adhesive affected bonding

positively compared to wood*PMMA samples from Cz oak tree that were bonded with PVac adhesive.

31. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree that were bonded with PVAc adhesive. In seventh chapter was given the results.

32. Wood*PMMA tested samples from Cz oak and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz oak tree that were bonded with PVAc adhesive.

33. Wood*wood tested samples from Cz spruce which were bonded with solvent adhesive differ from wood*wood tested samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*wood tested samples from Cz spruce tree that were bonded with solvent adhesive.

34. Wood*wood tested samples from Cz spruce which were bonded with solvent adhesive differ from wood*wood tested samples from Cz spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*wood samples from Cz spruce tree that were bonded with solvent adhesive.

35. Wood*wood tested samples from Cz spruce which were bonded with solvent adhesive differ from wood*wood samples from Cz spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*wood tested samples from Cz spruce tree that were bonded with solvent adhesive.

36. Wood*wood tested samples from Cz spruce which were bonded with epoxy adhesive differ from wood*wood samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*wood samples from Cz spruce tree that were bonded with epoxy adhesive.

37. Wood*wood tested samples from Cz spruce which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*wood samples from Cz spruce tree that were bonded with PVAc adhesive.

38. Wood*PC tested samples from Cz spruce and PC materials which were bonded with solvent adhesive differ from wood*wood tested samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with solvent adhesive.

39. Wood*PC tested samples from Cz spruce and PC material which were bonded with solvent adhesive differ from wood*wood tested samples from Cz spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with solvent adhesive.

40. Wood*PC tested samples from Cz spruce and PC material which were bonded with solvnet adhesive differ from wood*wood tested samples from Cz spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with solvent adhesive.

41. Wood*PC tested samples from Cz spruce and PC material which were bonded with solvent adhesive differ from wood*PC tested samples from Cz spruce and PC material bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz spruce wood and PC material that were bonded with epoxy

adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with solvent adhesive.

42. Wood*PC tested samples from Cz spruce which were bonded with PUR adhesive differ from wood*wood samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with PUR adhesive.

43. Wood*PC tested samples from Cz spruce and PC material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with PUR adhesive.

44. Wood*PC tested samples from Cz spruce and PC material which were bonded with PUR adhesive differ from wood*wood tested samples from Cz spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with PUR adhesive.

45. Wood*PC tested samples from Cz spruce and PC material which were bonded with PUR adhesive differ from wood*PC tested samples from Cz spruce wood and PC material bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz spruce wood and PC material that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with PUR adhesive.

46. Wood*PC tested samples from Cz spruce and PC material which were bonded with PUR adhesive differ from wood*PMMA tested samples from Cz spruce and PMMA material bonded with PVAc adhesive in adhesion resistance. Consequently, wood*PMMA tested samples from Cz spruce wood and PMMA material that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC material that were bonded with PUR adhesive.

47. Wood*PC tested samples from Cz spruce and PC materials which were bonded with PVAc adhesive differ from wood*wood tested samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree and PC materials that were bonded with PVAc adhesive.

48. Wood*PC tested samples from Cz spruce and PC material which were bonded with PVAc adhesive differ from wood*PC tested samples from Cz spruce and PC material bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz spruce wood and PC that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from Cz spruce tree that were bonded with PVAc adhesive.

49. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with solvent adhesive differ from wood*wood samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with solvent adhesive.

50. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with solvent adhesive differ from wood*wood tested samples from Cz spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA that were bonded with solvent adhesive.

51. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with solvent adhesive differ from wood-wood tested samples from Cz spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with solvent adhesive.

52. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with solvent adhesive differ from wood*PC tested samples from Cz spruce and PC material bonded with epoxy adhesive in adhesion resistance. Consequently,

wood*PC tested samples from Cz spruce wood and PC material that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with solvent adhesive.

53. Wood*PMMA tested samples from Cz spruce wood and PMMA material which were bonded with solvent adhesive differ from wood*PMMA tested samples from Cz spruce and PMMA material bonded with PVAc adhesive in adhesion resistance. Consequently, wood*PMMA tested samples from Cz spruce wood and PMMA material that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with solvent adhesive.

54. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with Epoxy adhesive differ from wood*wood tested samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with epoxy adhesive.

55. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with epoxy adhesive.

56. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from Cz spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA samples from Cz spruce tree and PMMA materials that were bonded with epoxy adhesive.

57. Wood*PMMA tested samples from Cz spruce and PMMA materials which were bonded with epoxy adhesive differ from wood*PC tested samples from Cz spruce and PC materials bonded with epoxy adhesive in adhesion resistance. Consequently, wood*PC tested samples from Cz spruce wood and PC material that were bonded with

epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree that were bonded with epoxy adhesive.

58. Wood*PMMA tested samples from Cz spruce and PMMA material which were bonded with PVAc adhesive differ from wood*wood samples from Cz spruce bonded with PUR adhesive in adhesion resistance. Consequently, wood*wood tested samples from Cz spruce wood that were bonded with PUR adhesive affected bonding positively compared to wood*PMMA tested samples from Cz spruce tree and PMMA material that were bonded with PVAc adhesive.

59. Wood*wood tested samples from T oak which were bonded with PVAc adhesive differ from wood*wood tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*wood tested samples from T oak tree that were bonded with PVAc adhesive.

60. Wood*PC tested samples from T oak and PC material which were bonded with epoxy adhesive differ from wood*wood tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with Epoxy adhesive affected bonding positively compared to wood*PC tested samples from T oak tree and PC material that were bonded with epoxy adhesive.

61. Wood*PC tested samples from T oak which were bonded with PVAc adhesive differ from wood*wood tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T oak tree that were bonded with PVAc adhesive.

62. Wood*PC tested samples from T oak and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from Toak bonded with PVAc adhesive in adhesion resistance. Consequently, wood-wood tested samples from T oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from T oak tree and PC material that were bonded with PVAc adhesive.

63. Wood*PC tested samples from T oak and PC material which were bonded with PVAc adhesive differ from wood*PC tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak

wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T oak tree and PC material that were bonded with PVAc adhesive.

64. Wood*PMMA tested samples from T oak and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T oak tree that were bonded with epoxy adhesive.

65. Wood*PMMA tested samples from T oak and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from T oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from T oak tree and PMMA materials that were bonded with epoxy adhesive.

66. Wood*PMMA tested samples from T oak and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from T oak bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T oak tree and PMMA materials that were bonded with PVAc adhesive.

67. Wood*PMMA tested samples from T oak and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from T oak bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from T oak wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from T oak tree and PMMA materials that were bonded with PVAc adhesive.

68. Wood*PC tested samples from T spruce and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from T spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T spruce tree and PC materials that were bonded with PVAc adhesive.

69. Wood*PC tested samples from T spruce and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from T spruce bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from T spruce wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from T spruce tree and PC materials that were bonded with PVAc adhesive.

70. Wood*PMMA tested samples from T spruce and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from T spruce bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T spruce wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T spruce tree and PMMA material that were bonded with PVAc adhesive.

71. Wood*PC tested samples from T cypress and PC material which were bonded with epoxy adhesive differ from wood*wood tested samples from T cypress bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T cypress wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T cypress tree and PC material that were bonded with epoxy adhesive.

72. Wood*PC tested samples from T cypress and PC material which were bonded with epoxy adhesive differ from wood*wood tested samples from T cypress bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples from T cypress wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from T cypress tree and PC material that were bonded with epoxy adhesive.

73. Wood*PC tested samples from T cypress and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from T cypress bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T cypress wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T cypress tree and PC material that were bonded with PVAc adhesive

74. Wood*PC tested samples from T cypress and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from T cypress bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood tested samples

from T cypress wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PC tested samples from T cypress tree and PC material that were bonded with PVAc adhesive.

75. Wood*PMMA tested samples from T cypress and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from T cypress bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood samples from T cypress wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T cypress tree and PMMA material that were bonded with epoxy adhesive

76. Wood*PMMA tested samples from T cypress and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from T cypress bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood samples from T cypress wood that were bonded with PVAc adhesive affected bonding positively compared to wood*PMMA tested samples from T cypress tree and PMMA material that were bonded with Epoxy adhesive.

77. Wood*PMMA tested samples from T cypress and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from T cypress bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T cypress wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T cypress tree and PMMA material that were bonded with PVAc adhesive.

78. Wood*PMMA tested samples from T cypress and PMMA material which were bonded with PVAc adhesive differ from wood*wood tested samples from T cypress bonded with PVAc adhesive in adhesion resistance. Consequently, wood*wood samples from T cypress wood that were bonded with PVAc adhesive affected bonding positively compared to wood-PMMA tested samples from T cypress tree and PMMA material that were bonded with PVAc adhesive

79. Wood*wood tested samples from T chestnut which were bonded with PVAc adhesive differ from wood*wood tested samples from T chestnut bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T chestnut wood that were bonded with Epoxy adhesive affected bonding positively compared to wood*wood tested samples from T chestnut tree that were bonded with PVAc adhesive.

80. Wood*PC tested samples from T chestnut and PC material which were bonded with epoxy adhesive differ from wood*wood tested samples from T chestnut bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T chestnut wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PC tested samples from T chestnut tree and PC material that were bonded with epoxy adhesive.

81. Wood*PC tested samples from T chestnut and PC material which were bonded with PVAc adhesive differ from wood*wood tested samples from T chestnut bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T chestnut wood that were bonded with Epoxy adhesive affected bonding positively compared to wood*PC tested samples from T chestnut tree and PC material that were bonded with PVAc adhesive.

82. Wood*PMMA tested samples from T chestnut and PMMA material which were bonded with epoxy adhesive differ from wood*wood tested samples from T chestnut bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood tested samples from T chestnut wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA samples from T chestnut tree and PMMA material that were bonded with epoxy adhesive.

83. Wood*PMMA tested samples from T chestnut and PMMA material which were bonded with PVAc adhesive differ from wood*wood samples from T chestnut bonded with epoxy adhesive in adhesion resistance. Consequently, wood*wood samples from T chestnut wood that were bonded with epoxy adhesive affected bonding positively compared to wood*PMMA tested samples from T chestnut tree and PMMA material that were bonded with PVAc adhesive. Results are shown in Table 25, Page 93.

Table 25: Statistics explaining the effects of kind of wood, materials that samples were taken from and kind of adhesive an adhesion resistance.

Tree	Layer	Kind of adh.	N	Mean (N/mm^2)	Std. Deviation	Std. Error	Different Groups	Bon. (P)
Cz Oak	Wood*Wood	Solvent	10	2.85	1.25941	.39826	1. Cz oak, wood*wood, solv. - Cz oak, wood*wood, PUR. 2. Cz oak, wood*wood, solv. - Cz oak, wood*wood, epoxy	.0001 .0001
		PUR.	10	9.61	2.35867	.74587	3.Cz oak, wood*wood, solvt. -Cz oak, wood*wood, PVAc 4.Cz oak, wood*wood, PVAc- Cz oak, wood*wood, Epoxy	.0001 .0001
		Epoxy	10	12.95	2.89231	.91463	5. Cz oak, wood*PC, solvt. - Cz oak, wood*wood, PUR 6. Cz oak, wood*PC, solvt. -Cz oak, wood*wood, Epoxy	.0001 .0001
		PVAc	10	8.41	2.18827	.69199	7. Cz oak, wood*PC, solvt. -Cz oak, wood*wood, PVAc 8. Cz oak, wood*PC, PUR.- Cz oak, wood*wood, PUR.	.0001 .0001
	Wood*PC	Solvent	10	1.62	.73153	.231332	9.Cz oak, wood*PC, PUR.- Cz oak, wood*wood, epoxy 10.Cz oak, wood*PC, PUR.- Cz oak, wood*wood, PVAc	.0001 .0001
		PUR.	10	-	-	-	11. Cz oak, wood*PC, PUR.- Cz oak, wood*PC, epoxy 12. Cz oak, wood*PC,PUR.- Cz oak, wood*PMMA, PVAc	.0001 .046
		Epoxy	10	4.44	1.20649	.38152	13. Cz oak, wood*PC, epoxy- Cz oak, wood*wood, PUR 14. Cz oak, wood*PC, epoxy- Cz oak, wood*wood, epoxy	.0001 .0001
		PVAc	10	2.24	.93854	.29679	15. Cz oak, wood*PC, epoxy- Cz oak, wood*wood, PVAc 16. Cz oak, wood*PC, PVAc- Cz oak, wood*Wood, PUR.	.0001 .0001
	Wood*PMMA	Solv.	10	1.95	.81913	.25903	17. Cz oak, wood*PC, PVAc- Cz oak, wood*wood, epoxy 18. Cz oak, wood*PC, PVAc- Cz oak, wood*wood, PVAc	.0001 .0001
		PUR.	10	-	-	-	19. Cz oak, wood*PMMA, solvt.- Cz oak, wood*wood, PUR. 20. Cz oak, wood*PMMA, solvt.- Cz oak, wood*wood, epoxy	.0001 .0001
		Epoxy	10	2.23	.57030	.18034	21. Cz oak, wood*PMMA, solvt- Cz oak, wood*wood, PVAc 22. Cz oak, wood*PMMA, PUR.- Cz oak, wood*wood, PUR.	.0001 .0001
		PVAc	10	3.44	1.54619	.48894	23. Cz oak, wood*PMMA, PUR.- Cz oak, wood*wood, epoxy 24. Cz oak, wood*PMMA, PUR.- Cz oak, wood*wood, PVAc	.0001 .0001
Cz Spruce	Wood*Wood	Solv.	10	2.12	.96105	.30391	26. Cz oak, wood-PMMA, PUR.- Cz oak, wood*PC, epoxy 27. Cz oak, wood*PMMA, epoxy - Cz oak, wood*wood, PUR.	.046 .0001
		PUR.	10	10.38	1.13532	.35902	28. Cz oak, wood*PMMA, epoxy- Cz oak, wood*wood, epoxy 29. Cz oak, wood*PMMA, epoxy - Cz oak, wood*wood, PVAc	.0001 .0001
		Epoxy	10	6.27	2.24618	.71030	30. Cz oak, wood*PMMA, PVAc - Cz oak, wood*wood, PUR 31. Cz oak, wood*PMMA, PVAc - Cz oak, wood*wood, Epoxy	.0001 .0001
		PVAc	10	5.80	1.37077	.43347	32. Cz oak, wood*PMMA, PVAc - Cz oak, wood*wood, PVAc 33. Cz spruce, wood*wood, solvt. - Cz spruce, wood*w, PUR	.0001 .0001
	Wood*PC	Solv.	10	1.34	.96312	.30456	34. Cz spruce, wood*wood, solvt. - Cz spruce, wood*w, epoxy 35. Cz spruce, wood*wood, solvt. - Cz spruce, wood*wo, PVAc	.0001 .012
		PUR.	10	-	-	-	36. Cz spruce, wood*wood, epoxy - Cz spruce, wood*woo, PUR 37. Cz spruce, wood*wood, PVAc - Cz spruce, wood*woo, PUR	.0001 .0001
		Epoxy	10	7.04	1.11531	.35269	38. Cz spruce, wood*PC, solvt - Cz spruce, wood*w, PUR. 39. Cz spruce, wood*PC, solvt- Cz spruce, wood*wood, Epoxy	.0001 .0001
		PVAc	10	3.39	1.34722	.42602	40. Cz spruce, wood*PC, solvt- Cz spruce, wood*wood, PVAc 41. Cz spruce, wood*PC, solvt - Cz spruce, wood*PC, Epoxy	.0001 .0001
	Wood* PMMA	Solv.	10	1.24	.64925	.20531	42. Cz spruce, wood*PC, PUR.- Cz spruce, Wood-wood, PUR. 43. Cz spruce, wood*PC, PUR. - Cz spruce, Wood-wood, Epoxy	.0001 .0001
		PUR.	10	-	-	-	44. Cz spruce, wood*PC, PUR. - Cz spruce, Wood*wood, PVAc 45. Cz spruce, wood*PC, PUR - Cz spruce, Wood*PC, Epoxy	.0001 .0001

… Continue of Table 25

		Epoxy	10	1.98	.86867	.27470	46. Cz spruce, wood*PC, PUR - Cz spr, wood*PMMA, PVAc 47. Cz spruce, wood*PC, PVAc - Cz spruce, wood*wood, PUR.	.0001 .0001
		PVAc	10	4.12	1.78700	.56510	48. Cz spruce, wood*PC, PVAc - Cz spruce, wood*PC, Epoxy 49. Cz spruce, wood-PMMA, solvt.- Cz spruce, wood*wo, PUR	.016 .0001
T Oak	Wood* Wood	Epoxy	30	10.11	3.06884	.56029	50. Cz spr, woo*PMMA, solvt. - Cz spruce, wood*wood, Epoxy 51. Cz spr, woo*PMMA, solvt. - Cz spruce, wood*wood, PVAc	.0001 .0001
		PVAc	30	7.89	2.54375	.46442	52. Cz spruce, w*PMMA, solvt. - Cz spruce, wood*PC, Epoxy 53. Cz spruce, w*PMMA, solvt. - Cz spr, wood*wood, PVAc	.0001 .0001
	Wood*PC	Epoxy	30	5.97	1.52045	.27759	54. Cz spruce, w*PMMA, epoxy- Cz spr, wood*wood, PUR. 55. Cz spruce, w*PMMA, epoxy - Cz spr, wood*wood, Epoxy	.0001 .0001
		PVAc	30	3.89	1.50246	.27431	56. Cz spruce, w*PMMA, epoxy - Cz spruce, wood*w, PVAc 57. Cz spruce, w*PMMA, epoxy-Cz spuce, wood*PC, epoxy	.006 .0001
	Wood* PMMA	Epoxy	30	4.08	1.60832	.29363	58. Cz spruce, w*PMMA, PVAc - Cz spruce, wood*wood, PUR 59. T oak, wood*wood, PVAc - T oak, wood*wood, epoxy	.0001. 005
		PVAc	30	5.75	1.52913	.27918	60. T oak, wood*PC, Epoxy - T oak, wood*wood, epoxy 61. T oak, wood *PC,PVAc- T oak, wood*wood, epoxy	.0001 .0001
T Spruce	Wood* Wood	Epoxy	30	7.44	2.06187	.37644	62. T oak, wood *PC, PVAc - T oak, wood* wood, PVAc 63. T oak, wood *PC, PVAc - T oak, wood*PC, epoxy	.0001 .020
		PVAc	30	6.53	1.77555	.32417	64. T oak, wood*PMMA, epoxy - T oak, wood*wood, epoxy 65. T oak, wood *PMMA, epoxy - T oak, wood*wood, PVAc	.0001 .0001
	Wood*PC	Epoxy	30	5.84	.84290	.15389	66. T oak, wood *PMMA, PVAc - T oak, wood *wood, epoxy 67. T oak, wood *PMMA, PVAc - T oak, wood * wood, PVAc	.0001 .013
		PVAc	30	3.99	1.06092	.19370	68. T spruce, wood*PC, PVAc - T spruce, wood*wood, epoxy 69. T spruce, wood*PC, PVAc - T spruce, wood *wood, PVAc	.0001 .0001
	Wood *PM	Epoxy	30	5.62	.94282	.17213	70. T spruce, w *PMMA, PVAc - T spruce, wood*w, epoxy	.0001
		PVAc	30	4.76	1.37395	.25084	71. T cypress, w *PC, epoxy - T cypress, wood*wood, epoxy	.0001
T Cypress	W* Woo	Epoxy	30	6.77	2.87651	.52517	72. T cypress, w *PC, epoxy - T cypress, wood*wood, PVAc	.0001
		PVAc	30	6.62	2.43496	.44456	73. T cypress, w*PC, PVAc - T cypress, wood*wood, epoxyy	.0001
	Woo d*P	Epoxy	30	4.03	1.95834	.35754	74. T cypress, w *PC, PVAc - T cypress, wood*wood, PVAc	.0001
		PVAc	30	3.39	1.40429	.25638	75. T cypress, w *PMMA, epoxy - T cypress, wood* wo, epoxy	.0001
	W* PM	Epoxy	30	3.91	1.53084	.27949	76. T cypress, w *PMMA, epoxy- T cypress, wood*w, PVAc	.0001
		PVAc	30	2.58	1.24650	.22757	77. T cypress, w*PMMA, PVAc - T cypress, wood*w, epoxy	.0001
T Chestnut	W* Woo	Epoxy	30	8.86	3.54396	.64703	78. T cypress, w *PMMA, PVAC - T cypress, wood*w, PVAc	.0001
		PVAc	30	5.18	2.91731	.53262	79. T chestnut, wo * wood, PVAc - T chestnut, wood*w, epoxy	.0001
	W* PC	Epoxy	30	4.44	1.64414	.30017	80. T chestnut, w *PC, epoxy - T chestnut , wood*wood, epoxy	.0001
		PVAc	30	4.03	1.84948	.33766	81. T chestnut, w*PC,PVAC - T chestnut, wood*wood, epoxy	.0001
	W*P MMA	Epoxy	30	4.74	1.37251	.25058	82. T chest, w *PMMA, epoxy -T chestnut, wood *wood, epoxy	.0001
		PVAc	30	5.04	2.31003	.42175	83. T chest., w *PMMA, PVAc - T chest., wood * wood, epoxy	.0001

Among the bonding strength test values for wooden material, materials samples taken from and type of adhesive, the highest result was obtained in Cz oak+ wood*wood+ epoxy (12.95 N/mm^2). Average values of the results obtained are given in the diagram in Figure 36, Page 96.

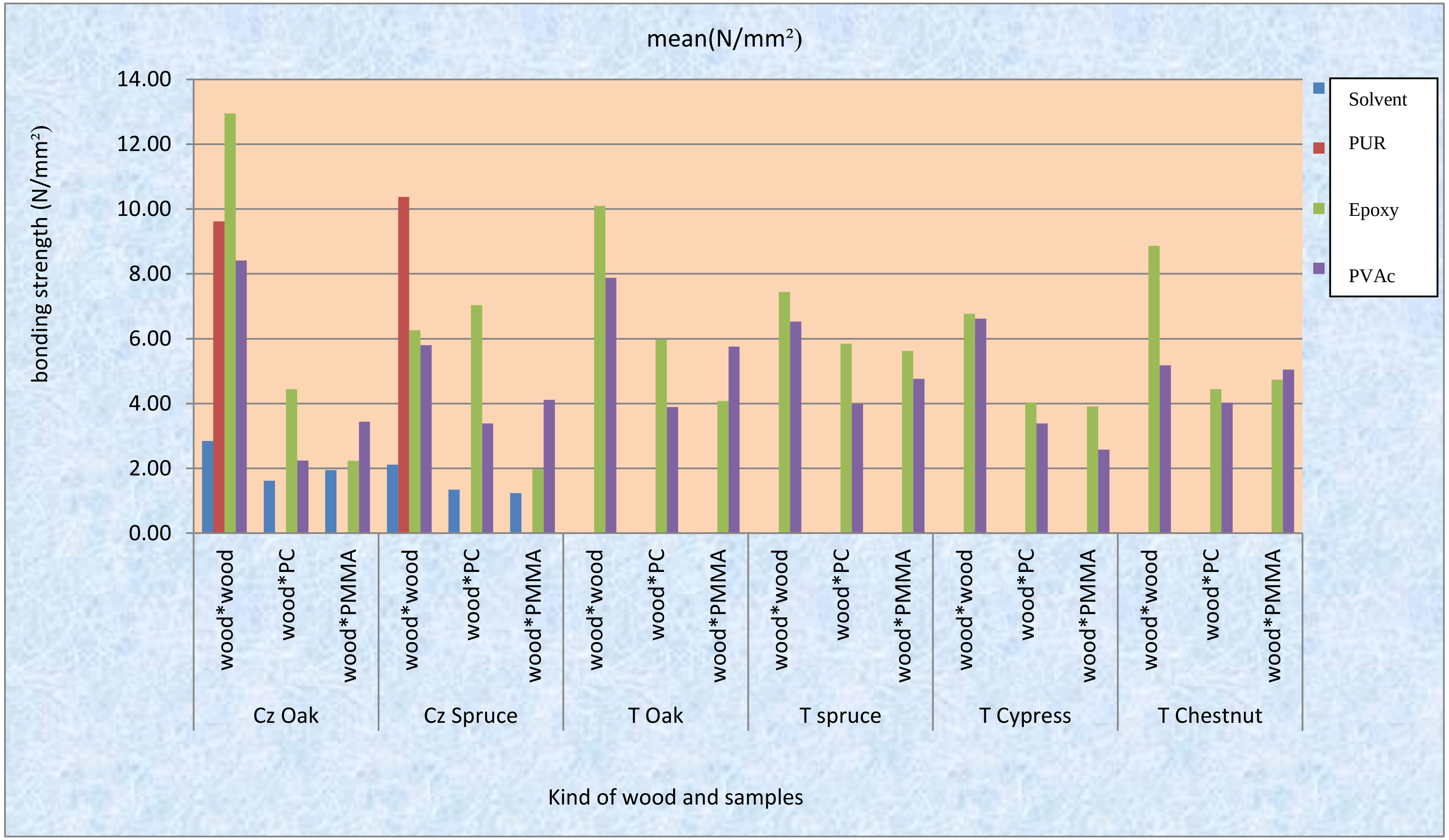


Figure 36: Average values of bonding strength for wooden material, material samples taken from type of adhesive.

7.3.1.5. Triple Comparison for Type of Wood, Type of Adhesive and Conditions after Adhesion

It was observed whether the interaction was significant for type of wood, type of adhesive and conditions after adhesion, and 5% significance level of interaction was found out to be significant (F= 7.063, P=.0001). To be able to see the variations; by evaluating the values of wood type, adhesive type and post-adhesion conditions together, they were turned into one variable and data set was rearranged. Data was tested with One-Way ANOVA and multiple comparison tests, Benforroni, were used. In the one-way variance analyses that was applied:

1. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the adhesion resistance values of Cz oak woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, tested samples from Cz oak woods which were bonded with epoxy adhesive and kept in room temperature has affected the adhesion positively compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

2. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the adhesion resistance values of the tested samples from Cz spruce woods which were bonded with epoxy adhesive and kept in room temperature. Consequently, samples from Cz spruce woods which were bonded with epoxy adhesive and kept in room temperature has given better results compared to the adhesion resistance values of the tested samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

3. Adhesion resistance values of the tested samples from Cz Oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, tested samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have affected adhesion positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

4. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature significantly differs from the tested samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, samples from T oak woods which were bonded with epoxy adhesive and kept in room tempreature had affected adhesion positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

5. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T oak woods which were bonded with epoxy adhesive and kept in the freezer. Consequently, samples from T oak woods which were bonded with epoxy adhesive and kept in the freezer had affected adhesion more positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

6. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T oak woods which were bonded with PVAc adhesive and kept in room temperature. As a result, tested samples from T oak woods which were bonded with PVAc adhesive and kept in room temperature had affected adhesion more positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

7. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T oak woods which were bonded with PVAc adhesive and kept in room temperature. As a result, tested samples from T oak woods which were bonded with PVAc adhesive and kept in room temperature had affected adhesion positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

8. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T oak woods which were bonded with PVAc adhesive and kept in cool chamber. As a result, tested samples from T oak woods which were bonded with PVAc adhesive and kept in cool chamber have given positive results in adhesion

compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

9. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T spruce woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, samples from T Spruce woods which were bonded with epoxy adhesive and kept in room temperature have affected adhesion positively compared to the samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

10. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T spruce wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, tested samples from T spruce wood which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion compared to the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

11. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T spruce woods which were bonded with epoxy adhesive and kept in the freezer. As a result, tested samples from T spruce wood which were bonded with epoxy adhesive and kept in the freezer have given better results in adhesion process compared to the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

12. Adhesion resistance values of the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T spruce wood which were bonded with PVAc adhesive and kept in room temperature. As a result, tested samples from T spruce wood which were bonded with PVAc adhesive and kept in room temperature have affected adhesion process positively compared to the tested samples from Cz oak woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

13. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T cypress woods which were bonded with epoxy adhesive and

kept in room temperature. Accordingly, tested samples from T cypress wood which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion process compared to the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

14. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T chestnut wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, from tested samples of T chestnut wood which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion process compared to the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

15. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T chestnut wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, higher values were gained from the tested samples of T chestnut wood which were bonded with epoxy adhesive and kept in room temperature compared to the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

16. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T chestnut wood which were bonded with epoxy adhesive and kept in the freezer. Accordingly, tested samples from T chestnut wood which were bonded with epoxy adhesive and kept in the freezer have given positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature.

17. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples from T chestnut wood which were bonded with PVAc adhesive and kept in room temperature. As a result, values of the tested samples from T chestnut wood which were bonded with PVAc adhesive and kept in room temperature have turned out to be positive in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

18. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from Cz oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, tested samples from Cz oak wood which were bonded with epoxy adhesive and kept in room temperature have affected adhesion process positively compared to the adhesion resistance values of the tested samples from Cz oak woods which were bonded with PUR adhesive and kept in room temperature and room humidity.

19. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, tested samples from Cz oak wood which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

20. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from T oak wood which were bonded with epoxy adhesive and kept in the freezer. Consequently, higher values were obtained in adhesion process from the tested samples of T oak woods which were bonded with epoxy adhesive and kept in the freezer compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

21. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from T oak wood which were bonded with PVAc adhesive and kept in room temperature. Accordingly, positive results were obtained in adhesion resistance from the tested samples of T oak wood which were bonded with PVAc adhesive and kept in room temperature compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

22. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from T spruce woods which were bonded with epoxy adhesive and kept in room temperature. Consequently, tested samples from T spruce woods which were bonded with epoxy adhesive and kept in room temperature have affected adhesion process positively compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

23. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples from T spruce wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, tested samples from T spruce wood which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

24. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the tested samples from T spruce wood which were bonded with epoxy adhesive and kept in the freezer. Consequently, positive results were obtained from the tested samples of T spruce woods which were bonded with epoxy adhesive and kept in the freezer compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

25. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples from T chestnut wood which were bonded with epoxy adhesive and kept in room temperature. As a result, tested samples from T chestnut woods which were bonded with epoxy adhesive and kept in room temperature have given positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

26. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the

samples of T chestnut wood which were bonded with epoxy adhesive and kept in the freezer. Consequently, adhesion resistance values of the tested samples from T chestnut wood which were bonded with epoxy adhesive and kept in the freezer have been higher compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

27. Adhesion resistance values of the tested samples from Cz oak wood which were bonded with PVAc adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the tested samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have revealed more positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz oak wood which were bonded with PVAc adhesive and kept in room temperature and room humidity.

28. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of Cz oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from Cz oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in adhesion resistance compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

29. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of Cz oak wood which were bonded with PVAc adhesive and kept in room temperature. Accordingly, adhesion resistance values of the tested samples from Cz oak wood which were bonded with PVAc adhesive and kept in room temperature have revealed more positive results in adhesion process compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

30. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of Cz spruce woods which were bonded with epoxy adhesive

and kept in room temperature. Accordigly, adhesion resistance values of the tested samples from Cz spruce wood which were bonded with epoxy adhesive and kept in room temperature have been higher compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

31. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of Cz spruce wood which were bonded with PVAc adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from Cz spruce wood which were bonded with PVAc adhesive and kept in room temperature have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

32. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have affected the adhesion process more positively compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

33. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

34 Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with epoxy adhesive and kept in the freezer. As a result, adhesion resistance values of the tested samples from T

oak wood which were bonded with epoxy adhesive and kept in the freezer have given higher results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

35. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with PVAc adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from T oak wood which were bonded with PVAc adhesive and kept in room temperature have affected adhesion process more positively compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

36. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with PVAc adhesive and kept in room temperature. Accordingly, adhesion resistance values of the tested samples from T oak woods which were bonded with PVAc adhesive and kept in temperature have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

37. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T oak wood which were bonded with PVAc adhesive and kept in the freezer. Consequently, adhesion resistance values of the tested samples from T oak wood which were bonded with PVAc adhesive and kept in the freezer have resulted more positively compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

38. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T spruce wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T spruce wood which were bonded with epoxy adhesive and kept in room temperature

have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

39. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T spruce wood which were bonded with epoxy adhesive and kept in room temperature. As a result, it has been observed that adhesion resistance values of the tested samples from T spruce wood which were bonded with epoxy adhesive and kept in environmental chamber have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

40. Adhesion resistance values of the samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T spruce woods which were bonded with epoxy adhesive and kept in the freezer. Accordingly, adhesion resistance values of the samples from T spruce woods which were bonded with epoxy adhesive and kept in the freezer have given more positive results compared to the adhesion resistance values of the samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature and room humidity.

41. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T spruce wood which were bonded with PVAc adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from T spruce wood which were bonded with PVAc adhesive and kept in room temperature have given higher results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with contact adhesive and kept in room temperature and room humidity.

42. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T spruce wood which were bonded with PVAc adhesive and kept in room temperature. Consequently, adhesion resistance values of the tested samples from T spruce wood which were bonded with PVAc adhesive and kept in room temperature have affected the adhesion process positively compared to the adhesion resistance

values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

43. Adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the tested samples of T spruce wood which were bonded with PVAc adhesive and kept in the freezer. As a result, adhesion resistance values of the tested samples from T spruce wood which were bonded with PVAc adhesive and kept in the freezer have given more positive results compared to the adhesion resistance values of the tested samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

44. Adhesion resistance values of the samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T cypress woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T cypress wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

45. Adhesion resistance values of the samples from Cz spruce woods which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T cypress wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the samples from T cypress wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

46. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T cypress wood which were bonded with PVAc adhesive and kept in the freezer. Consequently, adhesion resistance values of the samples from T cypress wood which were bonded with PVAc adhesive and kept in the freezer have affected the bonding process more positively compared to the adhesion resistance values of the

samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

47. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from T chestnut wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

48. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, positive results were obtained from the adhesion resistance values of the samples from T chestnut wood which were bonded with epoxy adhesive and kept in room temperature compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

49. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with epoxy adhesive and kept in the freezer. Consequently, adhesion resistance values of the samples from T chestnut wood which were bonded with epoxy adhesive and kept in the freezer have given more positive results in bonding process compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

50. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with PVAc adhesive and kept in environmental chamber. Accordingly, higher values were obtained from the adhesion resistance values of the samples of T chestnut wood which were bonded with PVAc adhesive and kept in room temperature to the adhesion resistance values of the samples

from Cz spruce wood which were bonded withsolvent adhesive and kept in room temperature and room humidity.

51. Adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with PVAc adhesive and kept in the freezer. Consequently, adhesion resistance values of the samples from T chestnut wood which were bonded with PVAc adhesive and kept in the freezer have given more positive results compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with solvent adhesive and kept in room temperature and room humidity.

52. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples of Cz oak wood which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from Cz oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

53. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results bonding process compared to the adhesion resistance values of the samples from Cz spruce woods which were bonded with PUR adhesive and kept in room temperature and room humidity.

54. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples of T spruce wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T spruce woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in adhesion process compared to the adhesion resistance

values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

55. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples of T spruce wood which were bonded with epoxy adhesive and kept in the freezer. Consequently, adhesion resistance values of the samples from T spruce woods which were bonded with epoxy adhesive and kept in the freezer have given more positive results compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

56. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature differs significantly from the samples of T chestnut wood which were bonded with epoxy adhesive and kept in the freezer. Accordingly, adhesion resistance values of the samples from T chestnut wood which were bonded with epoxy adhesive and kept in the freezer have given more positive results compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with PUR adhesive and kept in room temperature and room humidity.

57. Adhesion resistance values of the samples from Cz spruce wood which were bonded with epoxy adhesive and kept in room temperature differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in adhesion process compared to the adhesion resistance values of the samples from Cz spruce wood which were bonded with epoxy adhesive and kept in room temperature and room humidity.

58. Adhesion resistance values of the samples from Cz spruce wood which were bonded with PVAc adhesive and kept in room temperature differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results compared to the adhesion resistance values of the samples

from Cz spruce wood which were bonded with PVAc adhesive and kept in room temperature and room humidity.

59. Adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature and room humidity.

60. Adhesion resistance values of the samples from T oak wood which were bonded with PVAc adhesive and kept in the freezer differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T oak woods which were bonded with PVAc adhesive and kept in the freezer.

61. Adhesion resistance values of the samples from T spruce woods which were bonded with PVAc adhesive and kept in environmental chamber differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T spruce woods which were bonded with PVAc adhesive and kept in environmental chamber.

62. Adhesion resistance values of the samples from T spruce wood which were bonded with PVAc adhesive and kept in the freezer differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T spruce wood which were bonded with PVAc adhesive and kept in the freezer.

63. Adhesion resistance values of the samples from T cypress wood which were bonded with epoxy adhesive and kept in room temperature differs significantly from the samples of T oak wood which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak wood which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with epoxy adhesive and kept in room temperature and room humidity.

64. Adhesion resistance values of the samples from T cypress woods which were bonded with epoxy adhesive and kept in room temperature differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in adhesion process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with epoxy adhesive and kept in room temperature and room humidity.

65. Adhesion resistance values of the samples from T cypress woods which were bonded with epoxy adhesive and kept in the freezer differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with epoxy adhesive and kept in the freezer.

66. Adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in room temperature differs significantly from the samples of Cz oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from Cz oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in room temperature and room humidity.

67. Adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in room temperature differs significantly from the samples of T spruce woods which were bonded with epoxy adhesive and kept in the freezer. Accordingly, adhesion resistance values of the samples from T spruce woods which were bonded with epoxy adhesive and kept in the freezer have given more positive results in bonding process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in room temperature and room humidity.

68. Adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in the freezer differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T cypress woods which were bonded with PVAc adhesive and kept in the the freezer.

69. Adhesion resistance values of the samples from T chestnut woods which were bonded with epoxy adhesive and kept in room temperature differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T chestnut woods which were bonded with epoxy adhesive and kept in room temperature.

70. Adhesion resistance values of the samples from T chestnut woods which were bonded with PVAc adhesive and kept in room temperature differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. As a result, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T chestnut woods which were bonded with PVAc adhesive and kept in room temperature and room humidity.

71. Adhesion resistance values of the samples from T chestnut woods which were bonded with PVAc adhesive and kept in room temperature differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Accordingly, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T chestnut woods which were bonded with PVAc adhesive and kept in room temperature and room humidity.

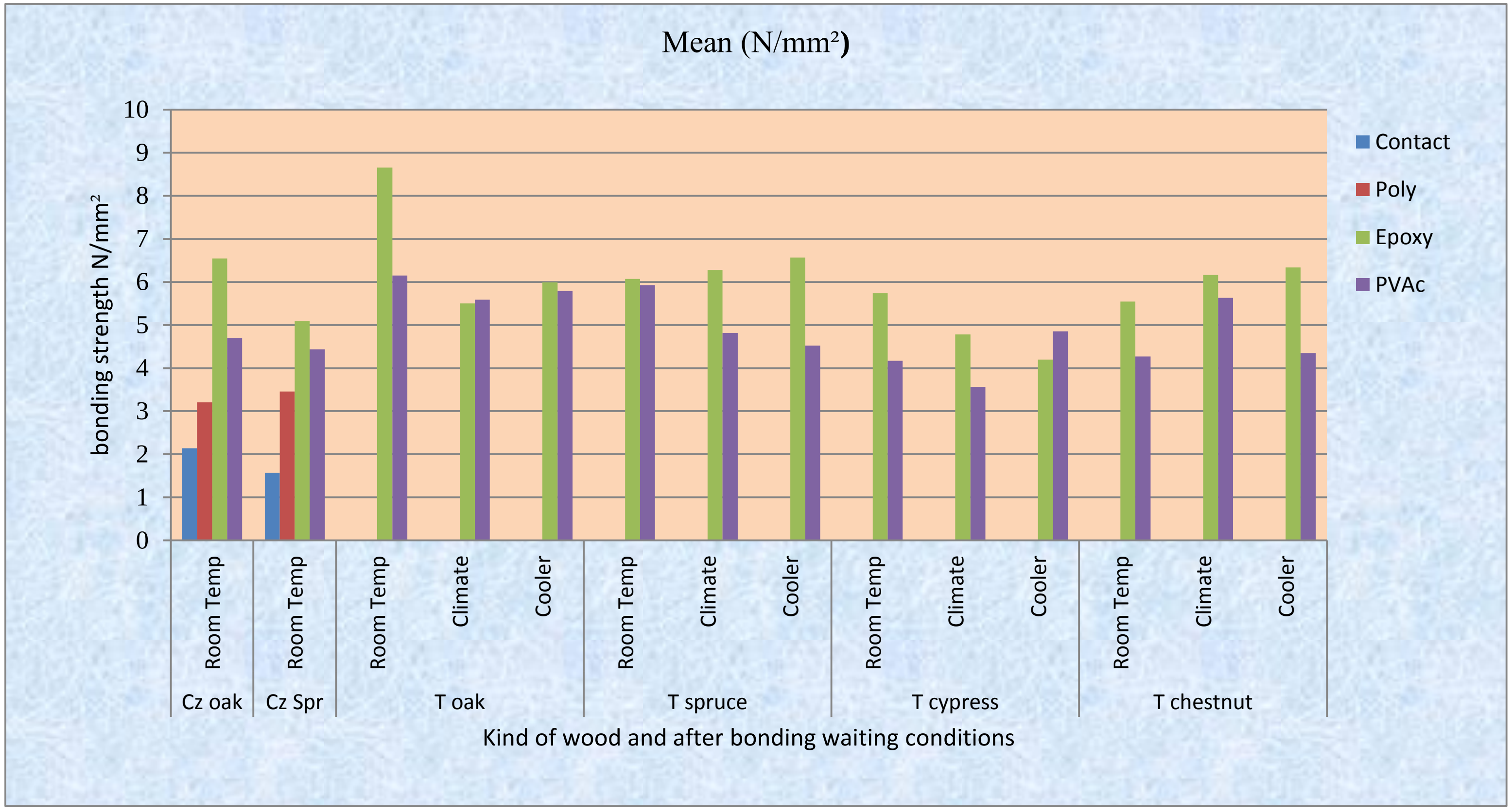
72. Adhesion resistance values of the tested samples from T chestnut woods which were bonded with PVAc adhesive and kept in the freezer differs significantly from the samples of T oak woods which were bonded with epoxy adhesive and kept in room temperature. Consequently, adhesion resistance values of the samples from T oak woods which were bonded with epoxy adhesive and kept in room temperature have given more positive results in bonding process compared to the adhesion resistance values of the samples from T chestnut woods which were bonded with PVAc adhesive and kept in the the freezer. Results obtained from the study are given in Table 26, Page 115.

Table 26: Statistical effets of wood type, type of adhesive and conditions after adhesion on adhesion resistance.

Trees	Adhesives	Contitations	N	Mean	Std. Deviation	Different Groups	Bon. (P)
Cz oak	Solv.	Room Temp.	30	2.14	1.07019	1. Cz oak, solvt., room temp. – Cz oak, epoxy, room temp. 2. Cz oak, solvt., room temp. – Cz spr., epoxy, room temp.	.0001 .017
	PUR	Room Temp.	30	3.21	4.79513	3. Cz oak, solvt., room temp. – T oak, epoxy, room temp. 4. Cz oak, solvt., room temp. – T oak, epoxy, high temp	.0001 .001
	Epoxy	Room Temp.	30	6.54	5.02296	5. Cz oak, solvt., room temp. – T oak, Epoxy, the freezer 6. Cz oak, solvt, room temp. – T oak, PVAc, room temp	.0001 .0001
	PVAc	Room Temp.	30	4.70	3.14418	7. Cz oak, solvt, room temp. – T oak, PVAc, high temp 8. Cz oak, solvt., room temp. – T oak, PVAc, the freezer	.001 .0001
Cz spruce	Solv.	Room Temp.	30	1.57	.929520	9. Cz oak, solvt. room temp. – T spr., epoxy, room temp. 10. Cz oak, solvt, room temp. – T spruce, epoxy, high temp	.0001 .0001
	PUR	Room Temp.	30	3.46	5.01347	11. Cz oak, solvt., room temp. – T spruce, epoxy, the freezer 12. Cz oak, solvt., room temp – T spruce, PVAc, room temp	.0001 .0001
	Epoxy	Room Temp.	30	5.10	2.70413	13. Cz oak, solvt., room temp – T cypres, epoxy, room temp. 14. Cz oak, solvt, room temp – T chestnt, epoxy, room temp.	.001 .0001
	PVAc	Room Temp.	30	4.44	1.78794	15. Cz oak, solvt., room temp – T chestnut, epoxy, high temp 16. Cz oak, solvt, room temp – T chest., epoxy., the freezer	.0001 .001
T oak	Epoxy	Room Temp.	30	8.66	3.76545	17. Cz oak, solvt, room temp – T chest., PVAc, high temp. 18. Cz oak, PUR, room temp. – Cz oak, epoxy, room temp.	.002 .0001
		High Temp.	30	5.50	2.91701	19. Cz oak, PUR, room temp. – T oak, epoxy, room temp. 20. Cz oak, PUR, room temp. – T oak, epoxy, the freezer.	.047 .018
		The freezer	30	5.99	2.29954	21. Cz oak, PUR, room temp. – T oak, PVAc., room temp. 22. Cz oak, PUR, room temp. – T spruce, epoxy, room temp.	.030 .009
	PVAc	Room Temp.	30	6.15	3.39145	23. Cz oak, PUR, room temp. – T spruce, epoxy, high temp 24. Cz oak, PUR, room temp – T spruce, epoxy., the freezer	.001 .017
		High Temp.	30	5.58	1.84203	25. Cz oak, PUR, room temp. – T chestnut, epoxy, high temp 26. Cz oak, PUR, room temp. – T chestnut, Ep., the freezer	.006 .0001
		The freezer	30	5.79	2.05902	27. Cz oak, PVAc, room temp. – T oak, epoxy, room temp. 28. Cz spr, solvt, room temp. – Cz oak, epoxy, room temp	.0001 .006
T spruce	Epoxy	Room Temp.	30	6.07	1.53603	29. Cz spr., solvt., room temp. – Cz oak, PVAc, room temp. 30. Cz spr, solvt., room temp. – Cz spr., epoxy, room temp.	.0001 .029
		High Temp.	30	6.28	1.88510	31. Cz spr., solvt., room temp. – Cz spr., PVAc., room temp. 32. Cz spruce, solvt, room temp. – T oak, epoxy, room temp.	.0001 .0001
		The freezer	30	6.57	1.35644	33. Cz spruce, solvt., room temp. – T oak, epoxy, high temp. 34. Cz spruce, solvt., room temp. – T oak, epoxy, the freezer	.0001 .0001
	PVAc	Room Temp.	30	5.93	1.82183	35. Cz spr., solvt., room temp. – T oak, PVAc, room temp. 36. Cz spr., solvt., room temp. – T oak, PVAc, high temp	.0001 .0001
		High Temp.	30	4.82	.959517	37. Cz spruce, solvt., room temp. – T oak, PVAc, the freezer 38. Cz spr, solvt., room temp. - T spruce, epoxy, room temp.	.0001 .0001
		The freezer	30	4.52	2.07318	39. Cz spr., solvt., room temp. – T spruce, epoxy. high temp. 40. Cz spruce, solvt., room temp. – T spruce, epoxy, the freezer	.0001 .0001
T cypress	Epoxy	Room Temp.	30	5.74	1.63498	41. Cz spr., solvt room temp. – T spr., PVAc, room temp. 42. Cz spr., solvt room temp. – T spr., PVAc, high temp.	.003 .017
		High Temp.	30	4.78	2.17800	43. Cz spr., solvt., room temp. – T spruce, PVAc, the freezer 44. Cz spr., solvt., room temp. – T cypress, epoxy. room temp.	.0001 .003
		The freezer	30	4.20	3.34866	45. Cz spr., solvt., room temp. – T sypress, epoxy. high temp. 46. Cz spr., solvt., room temp. – T sypr., PVAc., the freezer	.002 .0001
	PVAc	Room Temp.	30	4.17	3.28550	47. Cz spr., solvt., room temp. – T chest., epoxy, room temp. 48. Cz spr., solvt, room temp. – T chestnut, epoxy, high temp. 49. Cz spr., solvt., room temp. – T chestnut, epoxy, the freezer	.0001 .0001 .0001
		High Temp.	30	3.57	1.84799	50. Cz spr., solvt, room temp. – T chest., PVAc, high temp. 51. Cz spr., solvt., room temp. – T chest., PVAc, the freezer	.048 .008
		The freezer	30	4.85	1.96675	52. Cz spruce, PUR, room temp. – Cz oak, epoxy, room temp. 53. Cz spruce, PUR, room temp. – T oak, epoxy, room temp. 54. Cz spr., PUR, room temp. – T spruce, epoxy, high temp.	.0001 .039 .007
T Chestnut	Epox	Room Temp.	30	5.55	1.39992	55. Cz spruce, PUR, room temp. – T spruce, epoxy, the freezer 56. Cz spr., PUR., room temp. – T chestnut, epoxy, the freezer 57. Cz spruce, epoxy, room temp. – T oak, epoxy, room temp.	.028 .0001 .0001
		High Temp.	30	6.16	3.13579	58. Cz spruce, PVAc, room temp. – T oak, epoxy, room temp. 59. T oak, epoxy, high temp. - T oak, epoxy, room temp. 60. T oak, PVAc, the freezer - T oak, epoxy, room temp.	.005 .029 .0001

… Continue of Table 26							
		The freezer	30	6.33	4.20112	61. T spr.,PVAc, high temp. - T oak, epoxy, room temp. 62. T spr.,PVAc, the freezer - T oak, epoxy, room temp. 63. T sypr. epoxy, room temp - T oak, epoxy, room temp.	.0001 .0001 .021
	PVAc	Room Temp.	30	4.27	2.65963	64. T sypr. epoxy, high temp. - T oak, epoxy, room temp. 65. T sypr. epoxy, the freezer - T oak, epoxy, room temp. 66. T sypr. PVAc, high temp – Cz oak, epoxy, room temp.	.0001 .0001 .015
		High Temp.	30	5.63	1.77482	67. T sypr. PVAc, high temp – T spr. epoxy, the freezer 68. T sypr. PVAc, freezer – T oak, epoxy, room temp. 69. T chest. epoxy, room temp. - T oak, epoxy, room temp.	.013 .0001 .007
		The freezer	30	4.35	2.57987	70. T chest, PVAc, room temp - T oak, epoxy, room temp. 71. T chest, PVAc, high temp - T oak, epoxy, room temp. 72. T chest, PVAc, the freezer - T oak, epoxy., room temp.	.0001 .011 .0001

Adhesion resistance test for type of wood, type of adhesive and samples' waiting conditions after adhesion has been analyzed graphically. Hereunder, highest value for adhesion has been obtained from the samples of T oak woods which were bonded with epoxy adhesive. Results are given in Figure 37, Page 117.



Solvent

PUR

Epoxy

PVAc

Figure 37: Adhesion resistance test for type of wood, type of adhesive and adhesion keeping condition.

7.3.1.6. Quaternary Comparison for Type of Wood, Type of Adhesive, Layer from Which the Samples Were Taken and after Adhesion Keeping Conditions

In adhesion resistance test, as a last step, it was searched whether there was a loss in resistance in percentages (%) in the adhesion resistance values of the samples from solid wooden materials compared to PC, PMMA and the ones derived by bonding solid wooden materials. Hereunder:

1. In all the samples obtained from PC and PMMA materials, adhesion resistance values for PUR and solvent adhesive have turned out to be negative.
2. For wood to wood samples: adhesion resistance values resulted positively for Cz oak woods bonded with epoxy adhesive (wood*PC) and kept in room temperature, T chestnut woods bonded with epoxy adhesive (wood*PC and wood*PMMA) and kept in room temperature, T chestnut woods bonded with PVAc adhesive (wood*PMMA).
3. For wood to wood samples: there has been a loss of adhesion resistance up to 80 % in Cz oak woods bonded with epoxy adhesive (wood*PMMA) and kept in room temperature, T oak woods bonded with epoxy adhesive (wood*PMMA) and kept in environmental chamber and T cypress woods bonded with PVAc adhesive (wood*PMMA). Results obtained from the study are given in Table 27, Page 119

Table 27: Loss of the adhesion resistance (%) af the other samples compared to wood to wood bonded samples as a result of the adhesşon resistance test (N/mm^2).

Kind of wood, adhesive, layers and conditions after adhesion			N	Cz oak Mean	Cz oak Std. Deviation	Cz oak % Decrease	Cz spruce Mean	Cz spruce Std. Deviation	Cz spruce % Decrease
Solvent	Wood*wood	Room temp.	10	2.85	1.25941	-	2.12	.96105	-
	Wood*PC		10	1.62	.73153	43.08	1.34	.96312	36.50
	Wood*PMMA		10	1.95	.81913	31.69	1.24	.64925	41.50
PUR	Wood*wood		10	9.62	2.35867	-	10.37	1.13532	-
	Wood*PC		10	.00	.00000	100	.00	.00000	100
	Wood*PMMA		10	.00	.00000	100	.00	.00000	100
Epoxy	Wood*wood		10	12.95	2.89231	-	6.27	2.24618	-
	Wood*PC		10	4.44	1.20649	65.68	7.04*	1.11531	+12.24
	Wood*PMMA		10	2.23	.57030	82.76	1.98	.86867	68.47
PVAc	Wood*wood		10	8.41	2.18827	-	5.80	1.37077	-
	Wood*PC		10	2.24	.93854	73.37	3.39	1.34722	41.62
	Wood*PMMA		10	3.44	1.54619	59.12	4.12	1.78700	29.05
				T oak			**T spruce**		
Epoxy	Wood*wood	Room temp.	10	13.53	.83807	-	6.84	1.99696	-
	Wood*PC		10	7.46	.86327	44.96	5.44	.94918	20.55
	Wood*PMMA		10	4.98	1.13731	63.24	5.93	1.25786	13.34
	Wood*wood	High Temp.	10	9.09	.57856	-	7.16	2.87889	-
	Wood*PC		10	4.97	.43580	45.26	6.47	.67635	9.58
	Wood*PMMA		10	2.46	1.41974	72.95	5.20	.71298	27.37
	Wood*wood	The freezer	10	7.70	2.94842	-	8.32	.26904	-
	Wood*PC		10	5.47	1.63045	28.93	5.62	.50497	32.44
	Wood*PMMA		10	4.81	.77504	37.51	5.75	.67044	30.87
PVAc	Wood*wood	Room	10	8.87	4.04926	-	8.27	1.12427	-
	Wood*PC		10	3.36	1.68441	62.12	4.48	.23677	45.12
	Wood*PMMA		10	6.22	.96479	29.90	5.04	.27295	39.02
	Wood*wood	High Temp.	10	7.44	.56457	-	5.16	.87160	-
	Wood*PC		10	3.44	1.18137	53.68	4.28	1.12305	17.19
	Wood*PMMA		10	5.88	.47444	20.97	5.02	.66254	2.69
	Wood*wood	The freezer	10	7.33	1.57328	-	6.15	1.59219	-
	Wood*PC		10	4.87	1.20296	33.56	3.20	1.12718	47.87
	Wood*PMMA		10	5.17	2.39568	29.45	4.22	2.25302	31.40
				T cypress			**T chestnut**		
Epoxy	Wood*wood	Room	10	6.50	1.65307	-	5.26	1.87314	-
	Wood*PC		10	5.99	1.75921	7.74	6.09*	1.29577	+15.55
	Wood*PMMA		10	4.72	.96360	27.31	5.30*	.80930	+0.79
	Wood*wood	Te	10	6.41	2.88193	-	9.72	2.13406	-

… Continue of Table 27										
	Wood*PC	High	10	3.17	.35907	50.57	3.52	.90056	63.83
	Wood*PMMA		10	4.76	1.00690	25.79	5.24	1.87192	46.10
	Wood*wood	The freezer	10	7.41	3.86449	-	11.61	2.96625	-
	Wood*PC		10	2.94	1.64895	60.29	3.72	1.31159	67.92
	Wood*PMMA		10	2.25	1.00214	69.70	3.67	.09486	68.37
PVAc	Wood*wood	Room temp	10	7.41	3.86449	-	5.51	3.49133	-
	Wood*PC		10	1.78	.26553	75.43	2.81	1.13570	48.95
	Wood*PMMA		10	3.31	.96588	55.38	4.50	2.27841	18.28
	Wood*wood	High Temp.	10	5.59	.40837	-	5.99	2.97372	-
	Wood*PC		10	3.67	.86380	34.34	5.96	.29507	0.49
	Wood*PMMA		10	1.45	.76253	74.00	4.95	.66337	17.38
	Wood*wood	The freezer	10	6.87	1.43025	-	4.04	2.02468	-
	Wood*PC		10	4.72	.79441	31.33	3.32	1.81744	17.82
	Wood*PMMA		10	2.97	1.14896	56.74	5.69	3.28074	+40.87

When the adhesion resistance test was generally evaluated; the highest average adhesion resistance values were obtained from T oak wood (wood*wood) bonded with epoxy adhesive and kept in room temperature (13.5 N/mm^2) and Cz oak wood (wood*wood) bonded with epoxy adhesive (12.9 N/mm^2) and kept in room temperature. Positive results could not be obtained from all the samples bonded with contact adhesive. Adhesion resistance values could not be obtained from the PC and PMMA samples bonded with polyurethane adhesive. Results are given in Table 28, 121.

Table 28: Duncan test results for the loss of adhesion resistance (N/mm^2).

Situation	Mean	H.G	Situation	Mean	H.G
T oak, ep., wood*wood, room temp.	13.5	A	T spr., ep., wood*PMMA, high temp.	5.2	G
Cz oak, ep., wood*wood, room temp.	12.9	A	Toak PVAc, wood*PMMA, the freezer	5.2	G
T chest., epoxy, wood*wood, the freezer	11.6	B	T spr., PVAc, wood*wood, high temp.	5.2	G
Cz spr., poly., wood*wood, room. temp.	10.4	B	T spr., PVAc, wood*PMMA, room temp.	5.0	G
T chest., epoxy, wood*wood, high temp.	9.7	C	T spr., PVAc, wood*PMMA, high temp.	5.0	G
Cz oak, PUR., wood*wood, room. temp.	9.6	C	T oak, ep., wood*PMMA, room temp.	5.0	G
T oak, epoxy, wood*wood, high temp.	9.1	C	T oak, epoxy, wood*PC, high temp.	5.0	G
T oak, PVAc, wood*wood, room temp.	8.9	C	T chest., PVAc, wood*PMMA, hight temp.	5.0	G
Cz oak, PVAc, wood*wood, room. temp.	8.4	D	T oak, PVAc, wood*PC, the freezer	4.9	H
T spruce, epoxy, wood*wood, the freezer	8.3	D	Toak epoxy, wood*PMMA, the freezer	4.8	H
T spr., PVAc, wood*wood, room temp.	8.3	D	T cyp., epoxy, wood*PMMA, high temp.	4.8	H
T oak, epoxy, wood*wood, the freezer	7.7	D	T cyp., ep., wood*PMMA, room temp.	4.7	H
T oak, epoxy, wood*PC, room temp.	7.5	E	T cypress, PVAc, wood*PC, the freezer	4.7	H
T oak, PVAc, wood*wood, high temp.	7.4	E	T chest., PVAc, wood*PMMA, roo temp.	4.5	H
T cypress, epoxy, wood*wood, the freezer	7.4	E	T spr., PVAc, wood*PC, room temp.	4.5	H
T cyp., PVAc, wood*wood, room temp.	7.4	E	Cz oak, epoxy, wood*PC, room temp.	4.4	H
T oak, PVAc, wood*wood, the freezer	7.3	E	T spruce, PVAc, wood*PC, high temp.	4.3	H
T spr., epoxy, wood*wood, high temp.	7.2	E	T spruce, PVAc, wood*PMMA, the freezer	4.2	H
Cz spr., epoxy, wood*PC, room temp.	7.0	E	Cz spr., PVAc, wood*PMMA, room temp.	4.1	H
T cypress, PVAc, wood*wood, the freezer	6.9	F	T chest., PVAc, wood*wood, the freezer	4.0	H
T spr., ep., wood*wood, room temp.	6.8	F	T chest., epoxy, wood*PC, the freezer	3.7	I
T cyp., ep., wood*wood, room temp.	6.5	F	T chest., epoxy, wood*PMMA, the freezer	3.7	I
T spr., epoxy, wood*PC, high temp.	6.5	F	T cypress, PVAc, wood*PC, high temp.	3.7	I
T cypress, epoxy, wood*wood, high temp.	6.4	F	T chestnut, epoxy, wood*PC, high temp.	3.5	I
Cz spr., epoxy, wood*wood, room temp.	6.3	F	T oak, PVAc, wood*PC, high temp.	3.4	I
T oak, PVAc, wood*PMMA, room temp.	6.2	F	Cz oak, PVAc, w*PMMA, room temp.	3.4	I
T spruce, PVAc, wood*wood, the freezer	6.1	F	Cz spr., PVAc, wood*PC, room temp.	3.4	I
T chestnut, epoxy, wood*PC, room temp.	6.1	F	T oak, PVAc, wood*PC, room temp.	3.4	I
T cypress, epoxy, wood*PC, room temp.	6.0	F	T chestnut, PVAc, wood*PC, the freezer	3.3	I
T chestnut, PVAc, wood*wood, high temp.	6.0	F	T cyp., PVAc, w*PMMA, room temp.	3.3	I
T chestnut, PVAc, wood*PC, high temp.	6.0	F	T spruce, PVAc, wood*PC, the freezer	3.2	I
T spr., epoxy, wood*PMMA, room temp.	5.9	G	T cypress, epoxy, wood*PC, high temp.	3.2	I
T oak, PVAc, wood*PMMA, high temp.	5.9	G	T cyp., PVAc, wood*PMMA, the freezer	3.0	I
Cz spr., PVAc, wood*wood, room temp.	5.8	G	T cypress, epoxy, wood*PC, the freezer	2.9	J
T spruce, epoxy, wood*PMMA, the freezer	5.8	G	Cz oak, cont., wood*wood, room temp.	2.8	J
T chest., PVAc, wood*PMMA, the freezer	5.7	G	T chest., PVAc, wood*PC, room temp.	2.8	J
T spruce, epoxy, wood*PC, the freezer	5.6	G	T oak, epoxy, wood*PMMA, high temp.	2.5	J
T cypress, PVAc, wood*wood, high temp.	5.6	G	T cyp., epoxy, wood*PMMA, the freezer	2.2	J
T chest., PVAc, wood*wood, room temp.	5.5	G	Cz oak, PVAc, wood*PC, room temp.	2.2	J
T oak, epoxy, wood*PC, the freezer	5.5	G	Cz oak, epoxy, w*PMMA, room temp.	2.2	J

… Continue of Table 28					
T spruce, epoxy, wood*PC, room temp.	5.4	G	Cz spr., solvent, wood*wood, room temp.	2.1	J
T chest., ep., wood*PMMA, room temp.	5.3	G	Cz spr., epoxy, w*PMMA, room temp.	2.0	J
T chest., epoxy, wood*wood, room temp.	5.3	G	Cz oak, solvent, w*PMMA, room temp.	1.9	K
T chest., epoxy, wood*PMMA, high temp.	5.2	G	T cyp., PVAc, wood*PC, room temp.	1.8	K
Cz oak, contact, wood*PC, room temp.	1.6	K	Cz oak, PUR, wood*PC, room temp.	0	L
T cyp., PVAc, wood*PMMA, high temp.	1.5	K	Cz oak, PUR, wood*PMMA, room temp.	0	L
Cz spr., solvent, wood*PC, room temp.	1.3	K	Cz spruce, PUR, wood*PC, room temp.	0	L
Cz spr., solvent, wood*PMMA, room temp.	1.2	K	Cz spr., PUR, wood*PMMA, room temp.	0	L

8. THE EVALUATION AND DISCUSSION OF THE RESULTS OF LABORATORY MEASUREMENTS

Analysis results of the laboratory measurements on the samples' density for all conditions

- Density of the samples from broad-leaved trees (Oak 0.94g/cm^3, Chestnut 0.86g/cm^3) has been calculated higher than the density results of samples' density from coniferous tree (e.i. Spruce 0.67g/cm^3 ve Cypress 0.78g/cm$^{3)}$. It was pointed out by Bozkurt (1982) and Yalıntırık and Efe (1994) in the literature that having dense cells for autumnal wood, a short lumen gap diameter and a thick cell wall are important factors affecting wood density in broad-leaved trees.
- It was seen that adhesive types do not affect the density of the samples in a significant level. The reason for this may be that enough amount of adhesive applied on the surfaces of the samples does not have a weight when it is dry.
- It was experienced that measurements of the samples after keeping in room temperature, high temperature and cold environment does not have any influence on density. Drying the samples in 103±2 ^{0}C temperature until they reach their constant-weight at first may have been effective in this situation.
- It was seen that plastic materials increase density in the samples which are combinations of wood and plastic materials (e.i. wood*wood 0.74 g/cm^3, wood*PC 0.87 g/cm^3 and wood*PMMA 0.82 g/cm^3). This means density of the chosen plastic material is higher than the wooden material's density.

Analysis results of the study on surface roughness

- First, surface roughness measurement was done in the cross direction to the fibers. Samples (oak, spruce) from Czech Republic and Turkey were compared. As a result, no significant difference was acquired from this analysis.
- Surface roughness (RA) values of coniferous trees (Cz spruce 7.88 µm, Tspruce 7.25 µm, T cypress 6.42 µm) are lower than the values of broad-leaved trees Cz oak 11.62 µm, T oak 10.59 µm, T chestnut 13.67 µm). Gurleyen (1998), in his research on the surface roughness of some tree species (i.e. yellow pine, oak and acacia), obtained the highest surface roughness value from oak wood samples. Even if wood surfaces are rasped or sanded well by using suitable techniques, they are not smooth because of the

cell gaps on them (Ulusoy, 2011). The reason of low surface roughness value in coniferous trees in comparion to broad-leaved trees may stem from homogeneous distribution of some factors like fiber structure in autumnal and spring wood, vessels, tracheids medullary rays (Sulaiman, 2009; Strumbo, 1963; Peters and Cumming, 1970).

- During surface roughness measurements, measurements that are parallel to the fibers are done lastly. Statistically significant differences could not be obtained between the samples (Cz spruce 4.99 µm, Cz oak 5.94 µm, T chestnut 6.64 µm, T oak 5.21 µm, T cypress 4.73 µm and T spruce 5.93 µm). According to results, it is clear that measurements parallel to the fibers are more indicative in determining the surface roughness of wooden material.

Analysis results of the adhesion resistance test

- Comparisons were made for different wood species. Maximum adhesion resistance value was obtained from the samples of T oak (6.28 N/mm^2). Minimum adhesion resistance value was obtained from Cz spruce wood (3.64). In a study by some researchers (Christiansen, 1990; Wiliams and Feist, 1999; and Aydın, 2004), it was stated that resin canals, resins and oher extractive substances may affect adhesion negatively. This information supports the high adhesion resistance value of oak wood which is one of the broad-leaved trees.
- Comparisons were done for different types of adhesives. Maximum adhesion resistance value was obtained from samples bonded with epoxy 1200 (5.96 N/mm^2). Minimum adhesion resistance value was obtained from samples bonded with Solvent adhesive (1.85 N/mm^2). Cheng (2013) analysed the bonding performance of PVC based WPC material with 5 different adhesives and he/she got the highest results from Epoxy adhesive. According to the result, structural adhesives may be choosen for wood and plastic combinations.
- Samples from the combinations were compared. Accordingly, wood-wood samples have given the maximum adhesion resistance value (7.39 N/mm^2). Low adhesion resistance values were obtained from wood-PC (3.96 N/mm^2) and wood-PMMA (3.89 N/mm^2) samples. 47 % adhesion resistance loss has been observed in wood-acrilic samples compared to the wood-wood samples. It should be remembered that surface energy level of plastic materials is different from that of wooden materials. Polymers known as organic compounds (for acrylics) are materials with low surface

energy (Goss, 2010; Kovan and Şekercioğlu 2005). For a stronger bonding, plastic materials should betreated in order to increase wettability capacity. (i.e. mechanical wearing, chemical etching, flame etching, corona and plasma treatments)

- Comparisons were done for after adhesion conditions. Average adhesion resistance value was 4.85 N/mm^2 for the samples kept in room temperature for 21 days. For the same period of time, adhesion resistance value for samples kept in high temperature is 5.29 N/mm^2 and 5.33 N/mm^2 for the ones in negative temperature.
- Paired comparison was done for wood species and types of adhesives. Maximum average adhesion resistance value (6.72 N/mm^2) was obtained from the samples of T oak bonded with Epoxy 1200 adhesive. Minimum average value (2.14 N/mm^2) was obtained from Cz oak wood samples bonded with Solvent adhesive. It was observed that structural characteristics and glues influence bonding positively. It is estimated that extractive substances in the nature of wood influence bonding negatively.
- Comparisons of wood species and sample combinations were done. As a result, wood-wood samples have given better results compared to wood-plastic samples. Maximum value (8.99 N/mm^2) was taken from wood-wood samples of T oak. Minimum average adhesion resistance value (2.08 N/mm^2) was obtained from wood-PC samples of Cz oak wood. It is recommended to use structural adhesives for a stronger bonding in wood*plastic combinations.
- Average adhesion resistance values of wood species and post-adhesion keeping conditions have been compared. Maximum adhesion resistance value has been obtained from T oak wood (7.41 N/mm^2) which was kept in room temperature. Minimum value was obtained from Cz spruce wood (3.64 N/mm^2) kept in room temperature. As a result, we may conlude that keeping broad-leaved species in room temperature does not influence bonding negatively.
- Effects of some factors as wood species, combinations that the samples taken from and types of adhesives on adhesion resistance have been analyzed statistically and the results were compared. Accordingly, wood*wood samples from all the wood species bonded with Epoxy, PVAc ad PUR adhesives have given better results compared to wood*plastic samples. Solvent and PUR adhesives have given better results in the adhesion of wood and plastic. It may be necessary to use these adhesives by strengthening their adhesion resistance and structures. Best results in wood*wood samples were obtained from Cz. oak (12.94 N/mm^2), T oak (10.10 N/mm^2), ve T

Chestnut (8.86 N/mm^2) which were bonded with Epoxy adhasive. In wood*plastic samples, the highest adhesion resistance value was obtained from Cz oak wood, wood*PC sample (7.03 N/mm^2), and T oak wood, wood*PC sample (5.9 N/mm^2) bonded with Epoxy adhesive.

- Effects of wood species, type of adhesive and post-adhesion conditions on adhesion resistance were analysed statistically. As a result; in each of the three conditions (i.e. room temperature, high temperature and the freezer condition), average adhesion resistance values were taken from the samples bonded with epoxy adhesive. Maximum adhesion resistance value was obtained from the samples of T oak wood bonded with Epoxy adhesive and kept in room temperature (8.65 N/mm^2). Minimum result was obtained from the samples of Cz spruce bonded with solvent adhesive and kept in room temperature (1.56 N/mm^2). It was concluded that wood species, adhesive type and post-adhesion conditions influence bonding positively or negatively.

- Quaternary comparison for type of wood, type of adhesive, layer from which the samples were taken and after adhesion keeping conditions. According to; in all the samples obtained from PC and PMMA materials, adhesion resistance values for polyurethane and contact adhesive have turned out to be negative (Table 27, Page 119) . For wood to wood samples: adhesion resistance values resulted positively for Cz spruce woods bonded with epoxy adhesive (wood*PC, 12 %) and kept in room temperature, T chestnut woods bonded with epoxy adhesive (wood*PC, 6 %)and wood*PMMA, 0.79 %) and kept in room temperature, T chestnut woods bonded with PVAc adhesive (wood*PMMA,40%). For wood to wood samples: there has been a loss of adhesion resistance up to 80 % in Cz oak woods bonded with epoxy adhesive (wood*PMMA,-82 %) and kept in room temperature, T oak woods bonded with epoxy adhesive (wood*PMMA, -72 %) and kept in hot temperature test chamber and T cypress woods bonded with PVAc adhesive (wood*PMMA, 68 %) kept in the freezer. When the adhesion resistance test was generally evaluated; the highest average adhesion resistance values were obtained from T oak wood (wood*wood) bonded with epoxy adhesive and kept in room temperature (13.5 N/mm2) and Cz oak wood (wood*wood) bonded with epoxy adhesive (12.9 N/mm2) and kept in room temperature. Positive results could not be obtained from all the samples bonded with contact adhesive. Adhesion resistance values could not be obtained from the PC and PMMA samples bonded with polyurethane adhesive (Table 27, Page 119).

- In this study, wooden materials were rasped in planning machine for the surface roughness and then measured. When the results of this study were analysed, it was seen that wood species and types of adhesives do not influence adhesion resistance significantly (bonding resistance values were given Table 28, Page 121 and surface roughnes Ra were given Table 12, page 55). Results from the study carried out by Martins, et al., (2013) referred in the literature corresponds with our evaluation.

9. APPLICATION OF INDUSTRY

It is a matter of fact that there is a rapid consumption of forest properties via natural disasters such as fire, flood, earthquake and lightening etc. and man-made effects like firewood, construction and woodworking etc. Thus, for wood which is an essential material for wood products industry the need for alternative materials has been a matter of consideration. Wood is anisotroph material together with plastic we do the niore isotropic material, esthetic influence of using the plastic. These are;

- Increasing the expected life time in the place of use (impregnation)
- Producing composite materials from wood wastes (MDF, chipboard, blockboard, OSB etc.)
- Panel plates produced from wood-plastic composites (WPC), wood wastes and plastic material wastes.
- Covering the surfaces of wood composites with plastic material. (membrane coating, plastic sidebands, PVC, ABS)
- Producing massive plastic panels.
- Nodescribing the production, but possible using of panels with good properties in public space, compare the properties od this panel with the properties of different panel.

The factors considered by the users of these products have been effective in the emergence of these alternative materials. These factors are construction, functionality, decoration and aesthetics.

Wood plastic board (WPB) panels known as Douplex which are subject to our study and mass-produced in Germany, Austria and Czech Republic are used as decorative materials. (Figure 8 and 9). However, they could not have taken an international place. It is a subject to be searched and developed.

WPD panels are produced in two different methods. First one is by bonding wooden panels on the surface of plastic material and second one is by bonding wooden and plastic boards side by side. Panels that are 5, 8 mm thick and 1000 mm x 2000 mm wide are produced by bonding wooden panels on plastic material with some gaps between each other. The ones that are 20 mm, 26 mm and 40 mm thick; and 1000 mm*2000 mm wide are produced by bonding laminates which are derived from plastic and wood separately.

Plastic materials that these panels produced from are matt, semi-matt or opaque and they may be treated with CNC machines easily. Along with these advantageous sides they come into prominence as decorative materials (Figure 10). In the production of these wood-plastic panels (WPD);

- Wood choice
- Appropriate plastics (PC, PMMA etc.)
- Appropriate adhesive choice is seen as an important factor that will increase the endurance and lifetime of the WPB panels in their place of use.

In furniture industry, panels may be used as seperators in corridor and office sections, some parts of the office furniture, cupboard doors (Figure 10), counter furnitures, shop display decorations (Figure 12), wall and ceiling covering, wardrobe door covering. They may be suggested to be used in interior design of cars and buses.

10. CONCLUSION

In this study, ıt was found out that density of materials from broad-leaved trees (i.e. oak and chestnut) is higher that that of coniferous trees (i.e.spruce and cypress). It was also found out that adhesive types and post-adhesion keeping conditions do not affect density severely, but plastic materials (i.e. PC and PMMA) increase the density of the samples. As can be understood from this result, it is a negative case for furniture industry. It may be suggested to use coniferous or low density trees in the production of these kinds of materials.

Surface roughness of some wood species taken from different regions such as Czech Republic and Turkey was measured and they were compared. However, no statistically significant difference was obtained. In measurements done on the vertical direction to the fibers significant differences could be obtained from RA values between wood species. Surface roughness values of coniferous trees turned out to be lower (positive) compared to broad-leaved tree species. It has been discovered that if someone wants to study surface roughness of tree species, they will have better results with the measurements vertical to fibers.

According to adhesion test results; in the comparison among wood species, broad-leaved trees have given higher adhesion resistance results. The reason may be that coniferous trees contain more resins, resin canals and other extractive substances than broad-leaved trees contain.

Adhesive types used in this study were analysed and the highest adhesion resistance values were derived from Epoxy 1200 adhesive. Any adhesion resistance value could not be obtained from wood*plastic combinations bonded with Solvent and PUR adhesives. It may be suggested to use Epoxy adhesive in the subsequent studies. If Solvent and PUR adhesives are to be used, they should be applied after strengthening their physical properties.

Combinations that samples were taken from were analysed. Although, mechanical wearing process was applied with 180 grit sand on plastic surfaces, 47 % adhesion resistance value loss was observed in wood*plastic samples compared to wood*wood samples. It was also pointed out in the literature reviews that plastic materials have lower surface energy than wooden materials have. In other words, bonding plastic materials with another material is a more difficult process compared to wooden material. Therefore, before bonding plastic materials, some processes should be applied to increase wettability.

In this study, there is no significant difference between PC and PMMA acrylic in the bonding process to wooden materials. But in the properties, which are the subject of future research.

In tenth chapter with regard to the findings from this study, to enhance the adhesion resistance of wood*plastic combinations:

- Wooden materials should not have knots, wood-decay fungus, resin, resin canals and extractive substances and they should be dried to minimum 10 % humidity.
- Adhesive: structural adhesives should be preferred in these kinds of studies.
- Plastic (Acrylic): pretreatments (i.e. mechanical wearing, chemical etching, flame etching, corona and plasma treatments) should be applied on plastic materials to enhance their wettability capacity.
- It is possible to say that after cleaning the surface, dampening it with a wet cloth will have an effect on increasing the adhesion resistance.

11. SUMMARY

Humankind have always wanted the furniture they have in their houses, workplaces and offices to be aesthetic, comfortable and decorative. It is a widely known fact that usage of plastic materials in furniture industry is increasing day by day. Surfaces plastic materials are used on composite wood for decorative and protective reasons. Another usage area for plastic materials is as sidebands to cover sides of compose wood. Nowadays, Wood Plastic Composites (WPC) panels are produced from certain amount of wood and plastic wastes. Currently, Wood Plastic Panels (WPP) formed by bonding solid plastics and wood are produced for decorative purposes.

In this study, we aimed to find answers for the following questions: How can plastic and wooden materials that are used for decorative purposes bond each other more strongly? What are the positive or negative sides that may be encountered? How can we shed light to subsequent studies?

For this purpose, Oak and Spruce wood from Czech Republic; and Oak, Spruce, Cypress and Chestnut wood from Turkis Republic were choosen. Plastic materials used in the experiment are Policorbonate (PC) ve Polymetilmetacralte (PMMA). Preferred adhesives are Solvent adhesive, polyurethane, polyvinylasetate (PVAc) ve epoxy 1200.

First, choosen wood species were dried in incubator between 100±3 ^{o}C until they reach their constant weight. Mechanical wearing treatment was applied with 180 grid sand on the surfaces of plastic materials.

Later, these processes were applied in sequence:

- Surface roughness values of wooden materials were determined to figure out whether wood species have an effect on adhesion resistance. Cz-200 surface roughness tester was used during the experiment.
- Samples were formed in the standarts of CSN EN 301-1 and CSN-302-1 for adhesion test. Total number of samples is 960.
- To determine the density of the samples, measurements (i.e. exact dry, after adhesion, after preesing and 21 days waiting duration) were done with a scale

which is in compliance with CSN 180 ve TS 241 standarts and can measure 0.01precision.

- After the adhesion process samples were categorized in to 3 of ten. They were kept in room temperature, high temperature and below zero degree for 21 days.
- Prepared samples were put through adhesion resistance test as an ultimate process.

As a result, density level of coniferous trees was lower than that of broad-leaved trees. An increase has been observed in the density of the samples formed with PC and PMMA.

In the surface roughness analysis, values of broad-leaved species were higher than coniferous species. Surface preparation treatments of the samples were only done with planner. Any positive or negative influence of it could not be detected on adhesion resistance.

In the adhesion resistance test analysis, all adhesive types had a positive effect on wood*wood samples. There has been 47 % resistance loss in the plastic*wood samples compared to wood*wood samples. No adhesion resistance value could not be obtained from from plastic*wood samples which were bonded with Solvent and PUR adhesives. Maximum values were obtained from wood*plastic samples bonded with structural Epoxy 1200. These have been some difficulties in the adhesion of plastic materials to wood. Thus, it was found out that before the adhesion of plastic materials, some pretreatments should definitely be conducted to increase wettability.

Main factors influencing adhesion resistance may be categorised as wooden material, adhesive, post-adhesion keeping conditions and sample formatiom combinations.

12. REFERENCES

Akyüz, M. (1997) "Doğu Ladini (*Picea Orientalis* (L) Link.) Odunun Fiziksel Ve Mekanik Özellikleri," *Orman Bakanlığı Doğu Karadeniz Ormancılık Araştırma Enstitüsü,*

American Instutite of Timber Construction. (1990) "Use of Epoxies in Repair of Structural Glued Laminated Timber," AITC Technical Note 14. AITC, Englrwood, CO.

Anonym. "TR-200 Surface Roughness Tester," Time Technology Europe, device instructions manual p. 18-22.

Anthony, L. A., and Mike, A. N. (2009) "Applications and societal benefits of plastics," Philosophical The royal of Society, vol. 364 no. 1526, 1977-1984.

As, N., Koç, K.H., Doğu, D., Atik, C., Aksu, B., Erdinler, S. (2001) "Anatomical, Physical, Mechanical and Chemical Properties of Industrially Important Trees Growing in Turkey," *İ.Ü. Faculty of Forestry Journal*, Serial: B, Volume: 51, Issue: 1, s. 71- 88 İstanbul.

ASTM D 905. (1998). "Standard Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading," *ASTM International*.

Aydın, Handan., vd. (2007) "History of Civilization, Anadolu University," *AÖF Publication,* Eskişehir.

Aydın, İ. (2004) "Effects of Some Production Conditions on Warming Quality of Coverings Obtained From Various Tree Species and Bonding Stregth," *Doctoral Thesis,* Karadeniz Technical University Institute of Science.

Aydın, İ., Çolakoğlu, G. (2003) "Methods of Measuring Roughness and Smoothness on Wood Surfaces," *Artvin Faculty of Forestry Journal,* Volume 1, Issue: 2, Page: 92-102.

Aydın, İ., Çolakoğlu, G., Akabulut, T. (2001) "Adhesion Theory on Bonding Wooden Material," *İ.Ü. Faculty of Forestry Journal,* Volume:51, Issue:2, Page: 91-99

Baldan, A. (2012) "Adhesion phenomena in bonded joints," *International Journal of Adhesion and Adhesives* 38(7), 95-116.

Balkız, Ö. (2000) "Researches on Detection of Bonding Features of Some Native Tree Species Used in Woodworking Industry," *Engineering Mater's Degree Thesis,* H.Ü. Instıtute of Science,Department of Woodworking Industrial Engineering, Ankara.

Bozkurt, A.Y. (1982) “Wood Technology,” *İ.Ü. Faculty of Forestry Publications*, Issue: 289, Page 128-135, İstanbul

Bozkurt, A.Y., Erdin, N. (1997) “Wood Technology,” *İ.Ü. Faculty of Forestry Publications,* Issue: 3998, Page 237-345, İstanbul.

Bozkurt, A.Y. (1992) “Odun Anatomisi,” *İ.Ü.Orman Fak.İ.Ü.Yayın* No:3652, Fakülte Yayın No:415, İstanbul.

Çakıcıer, N. (2007) “Changes Occuring as a Result of Aging on Wood Surface Process Layers,” *İstanbul University Institute of Science*, Page 82, İstanbul.

Cao, J.-Z., Li, L.-D., and Liu, Z. (2005) "Effect of ACQ-D treatment on the surface free energy of Chinese fir (*Cunninghamia lanceolata*)," *Forestry Studies in China* 7(4), 29-34.

Carpenter, M.V. (1999) “Characterizing The Chemistry of Yellow-Poplar Surfaces Exposed to Different Surface Energy Environments Using DCA, DSC and XPS, *Master Thesis,* West Virginia Universty.

Chan, C.M. (1993) “Polymer Surface Modification and Characterization,” Ch:7, *Hanser Publishers*, Germany.

Chau, T.T., Bruckard W.J., Koh P.T.L., Nguyen A.V. (2009) “A review of factors that affect contact angle and implications for flotation practice,” *International Journal of Adhesion and Adhesives*, 31, pp. 127-134.

Cheng, R. (2013) “The selestion of adhesive used to bon polyvinyl chloride/wood flour composites,” *Journal of adhesion Science and Technology,* Vol:27, No:24, 2696-2704.

Christiansen, A.W. (1990) “How Overdrying Wood Reduces Its Bonding to Phenol Formaldehyde Adhesives: A Critical Review of The Literature, Part I Physical Responses,” *Wood and Fiber Science* V.22,4, P. 441-459.

CSN EN 301-1. (2013) Adhesives, phenolic and aminoplastic, for load-bearing timber structures - Classification and performance requirements. Rebuplic of Chech Standard.

CSN EN 302-1. (2013) Adhesives for load-bearing timber structures - Test methods - Part 1: Determination of longitudinal tensile shear strength. Standart of Chech Republic.

ČSN EN 322. (1994) Wood-based panels. Determination of moisture content.

Debye, P.J.V. (1926) “Intertomic and Intermoleculer Forces in Adhesion and Cohesion,” Edited by Philips Weiss, *Elsevier Publishing Co,* New York, P.1-17.

Dunn, D.J. (2004) “Engineering and Structural Adhesives, Rapra Review Reports,” ISSN: 0889-3144 Volume 15, P. 3

Duran, V. (2005) “Effects of Wood Rasping Factors ob Surface Roughness,” *Master’s Thesis*, Zonguldak Karaelmas University, Institute of Science, Karabük.

Ebnesajjad, S. (2006) “Surface Treatment of materials for Adhesion Bonding,” *Wiliam Andrew Publishing*, USA.

FK drevené lišty, spol. s r. o. Bojanovice 79, 671 53, Jevišovice (www.fklisty.cz) date of access: 20.01.2013.

Funck, J.W., Forrer, J.B., Buttler, D.A., Brunner, C.C., Maristany, A.G. (1992) “Measuring Surface Roughness on Wood: AComparasion of Laser Scatter and Stylus Tracing Approaches,” *The International Society for Obtical Enginering (SPIE),* Vol. 1821, pp.173-184.

Gimpel, J. (1996) “Industrial Revolution in Medieval Age,” TÜBİTAK Publication, Ankara.

Gindl M., Sinn G., Gindl W., Reitener A., Tschegg S. (2001) “A comparison of different methods to calculate thee surface free energy of wood using contact angle measurements,” *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* 181, pp. 279-287.

Gindl, M., Reiterer, A., Sinn, G., and Stanzl-Tschegg, S.E. (2004) "Effects of surface ageing on wettability, surface chemistry, and adhesion of wood," *Holz als Roh- und Werkstoff* 62(4), 273-280.
Gindl, M., Reiterer, A., Sinn, G., and Stanzl-Tschegg, S.E. (2004) "Effects of surface ageing on wettability, surface chemistry, and adhesion of wood," *Holz als Roh- und Werkstoff* 62(4), 273-280.
Goss, B. (2010**)** “Pratical Guide to Adhesive Bonding of Small Engineering Plastic and Ruber Parts,” Ch: 6, *Smithhers Rapa*, UK.

Gürleyen, L. (1998) “Comparing Surface Roughness of Solid Wood Materials used in Furnishing,” *Master’s Thesis*, G.Ü. Institute of Science, Department of Furniture and Decoration, Ankara

Elias, H.G. (2000) "Plastics, General Survey" *Wiley Online Library*, Ullmann's ncyclopedia of Industrial Chemistry, DOI: 10.1002/14356007.a20_543

Hashim, S.A., and Loke, K.L. (2002) “The Behavıour of Adhesively Bonded-beams Versus Their Welded Equivalent,” Adhesion ’02. Proceedings of A conference Held Glasgow, 10th-13th Sept. p.39-42, London.

Heeger, A. J., Schrieffer, J. R., Su, W. P., Su, W. (1988) "Solitons in conducting polymers". *Reviews of Modern Physics* 60 (3): 781.

http://botit.botany.wisc.edu/botany_130/anatomy/Wood/Oak_wood.html. [Retrieved on: 14.10.2014].

http://plastikdunyasi.blogcu.com/akrilik-polimerler-nedir/11530493**.[**Redrieved on: 24.03.2013].

http://www.adhesiveandglue.com/adhesive-definition.html., [Retrieved on: 14.10.14].

http://www.awscales.com/portable-precision-scales-01-gram/141-mini-pro-50-compact -precision-balance. [Redrieved on: 11.10.2014**].**

http://www.eng.buffalo.edu/Courses/ce435/PC-CB.pdf **, [**Retrieved on: 22.7.2012].

http://www.geneq.com/catalog/en/roughness-tr200f.html., [Retrieved on: 8.8.2013**].**

http://www.inye.com.tw/product/heat-transfer-press-machine-do-4050-11-2h.html. [Retrieved on: 18.10.2014].

http://www.instron.us/en/products/testing-systems/universal-testing systems/ electromechanical/3300. [Redrieved on: 11.11.2014].

http://www.lg-dow.com/tech/tech.htm, [Retrieved on: 10.03.2013**]**

http://www.romaplastik.com., [Retrieved on: 14.10.2014].

http://www.sanorman.com., [Retrieved on: 04.02.2013].

http://www.surfaceandpanel.com/articles/finishing/demystifying-decorative-foil-finishes**.,** [Renrieved on 5.10.2013].

http://www.tece.com.tr., [Retrieved on: 15.3.2013].

http://www.venni.com.tr., [Retrieved on: 19.02.2013].

https://www.google.cz/search?q=poly+methyl+methacrylate+structure, **[**Retrieved on: 11.09.2013].

Huang, X., Kocaefe, D., Kocaefe, Y., Boluk, Y., and Pichette, A. (2012) "Changes in wettability of heat-treated wood due to artificial weathering," *Wood Science and Technology* 46(6), 1215-1237.

İlter, E., Çamlıyurt, C., Balkız, Ö. (2002) Researces on Determination of Uludağ Abies Wood's Surface Roughness, Publication Number: 175, Technical Bulletin, Issue: 281, Turkey.

ISO 4287. (1997) "Geometrical Product Specifications Surface Texture Profile Method"

Jennings, J. D., Zink-Sharp, A., Kamke, F. A., and Frazier, C. E. (2005) "Properties of compression densified wood. Part 1: bond performance," *Journal of Adhesion Science and Technology* 19(13-14), 1249-1261.

Kazayawoko, M. (1996) "Surface Characterization and Mechanism of Adhesion in Wood Fibre-Polypropylene Composites," *(PhD),* KTH-Royal Universty of Toronto

Kendall, K. (1994) "Adhesion: Molecules and Mechanics," *Science*, Vol. 263 no. 515 pp. 1720-1725.

Kent., R, "Periodic Table of Polymers," Tangram Techinology Ltd. Retrieved on 2014

Keohan, F.L., Adelstein J.B., and Arvanites, A.C. (1994) "Proceedings of the 39th International SAMPE Symposium, 1994, Volume I, 1130.

Kılıç, Y., Demirci, S. (2003) "Researching Surface Roughness Rates of Yellow Pine (Pinus sylvestris L.) ve Oak (Castanea sativa Mill.)," *G.Ü. Science Journal*, Volume: 16, Issue: 3, P. 553–558, Ankara.

Kinloch, A.J. (1987) Adhesion and Adhesives Science and Technology, Chapman and Hall, UK.

Kovan, V., Şekercioğlu, T. (2005) "Yapıştırma Bağlantılarında Yapışma teorileri ve Yüzey enerjilerinin incelenmesi," *Yüzey İşlemleri,* Sayı: 42, Sayfa: 22-26, Turkey.

Life cycle of a plastic product. Americanchemistry.com. Retrieved on 2013-07-01.

Little, N. S., McConnell, T. E., Irby, N. E., Shi, S. Q., and Riggins, J. J. (2013) "Surface free energy of blue-stained southern pine sapwood from bark beetle-attacked trees," *Wood and Fiber Science* 45(2), 206-214.

Madison, W. (2010) "Wood Handbook," *Forest Products Laboratory*, Chapter: 10, p: 13. United States.

Malkoçoğlu, A. ve Özdemir, T. (2003) "Türkiye'de Doğal Olarak Yetişen Önemli Bazı Ağaç Türleri Odunlarının İşlenme Özellikleri," *Proje Sonuç Raporu,* Trabzon.

Martins, S.A., **Del Menezzi, C.H.S., Ferraz., J.M., de Souza, M.R.** (2013) "Bonding Behavior of Eucalyptus benthamii Wood to Manufacture Edge Glued Panels" Maderas, *Ciencia y Tecnologia* 15(1): 79-92.

Merev, N. (1998) "Odun Anatomisi, Cilt 1, Doğu Karadeniz Bölgesinde Doğal Angiospermae Taksonlarının Odun Anatomisi," KTÜ, Orman Fak., KTÜ Genel Yayın No: 189. Fak. Yayın No:27, Trabzon, 1998

Nusret As vd, (2001) "Anatomical, Physical, Mechanical and Chemical Properties of Industrially Important Trees Growing in Turkey," *İ.Ü. Faculty of Forestry Journal*, Serial: B, Volume: 51, Issue: 1, İstanbul.

Örs, Y. (1987) "Mechanical Features of Finger Joint Solid Wood Material," Supplementary Book, K.T.U, Foresty Faculty, p. 29-34, Trabzon

Örs, Y., Atar, M., Özçifci, A (2000) "Bonding Strenght of Poly(viniyl acetate) Based Adhesives in some Wood Materials Treated with impreynation," *Journal of AppliedPolymer Science*, Vol. 76, (9), pp. 1472-1479, USA.

Örs, Y., Demirci, S. (2001) "Effects of Tooth Number in Circular Saw, Supply Rate and shearing Direction on Oak *(Quercus petreae L.)* and Acacia *(Robınıa pseudoacacıa L.)*," *Gazi University Institute of Science Journal, Volume*: 14, Issue: 3, P. 857-867, Ankara.

Örs, Y., Demirci, S. (2003) "Effects of Shearing Direction and Sanding on Surface Smoothness of Acacia (Robinia pseudoacacia L.) and Oak (Qercus petraea L.) Wood," *G.Ü. Politeknik Journal*, Volume: 6, Issue: 2, p. 491–495, Ankara

Örs, Y., Keskin, H (2001) "Technology of Wooden Material," *Nobel Publication Delivery*, p. 64-65.

Peters, C. C., Cumming, J. D. (1970) "Measuring wood surface smoothness," *A review. Forest Products Journal* 20 (12): 40-43.

Pizzi, A. (1994) "Brief Nonmathematical Review of Adhesion Theories as Applicable to Wood," *Advanced Wood Adhesive Technology*, V. 1.

Qin, Z., Gao, Q., Zhang, S., and Li, Z. (2014) "Surface Free Energy and Dynamic Wettability of Differently Machined Poplar Woods," *Bioresources*, 9(2), 3088-3103.

Rathke, J., and Sinn, G. (2013). "Evaluating the wettability of MUF resins and pMDI on two different OSB raw materials," *European Journal of Wood and Wood Products* 71(3), 335-342.

Richter, K., Feist. W.C., Knaebe, M.T. (1995) “The Efect of Surface Roughness on the Performance of Finishes,” *Forest Products Journal*, Vol. 45, No. 7, pp. 91-97.

Rodriguez, F., Cohen, C., Ober, C., Archer, L. (2003) “Principles of Polymer Systems,” *Taylor & Francis*, New York, London.

Roger M.R. (2005) “Handbook Of Wood Chemistry and Wood Composites,” Chapter 9-p, 45.

Şekercioğlu, T., and Kaner, S. (2013) “Invertigation of Surface Preparation methods for Bonding of Plastics,” *Mühendis ve Makine Magazine*, Cilt: 55, Sayı: 648, P:38-43, Turkey.

Sernek, M. (2001) “Inactivation of Wood Surfaces: A Literature Review,” Virginia Tech. University, *Wood-Based Composites Center*, Technical Report No. 103.

Shi, S. Q., and Gardner, D. J. (2001). "Dynamic adhesive wettability of wood," *Wood and Fiber Science* 33(1), 58-68.

Sieminski, R., Skarzynska, A. (1989) “Surface Roughness of Different Species of Wood After Sanding,” *Forest Products Journal*, Vol. 15, p.p. 23-25.

Terms, Definitions and Surface Texture Parameters, *International Standart Organization.*

Strumbo, D. A. (1963) “Surface texture measurement methods,” *Forest Products Journal* Ch: 13 (7), P: 299-304.

Sulaiman, O., Hashim, R., Subari, K., Liang, C. K. (2009) “Effect of sanding on surface roughness of rubberwood,” *Journal of Material Processing Technology* 209: 3949-3955.

Taylor, J. B., Carrano, A. L., Lemaster R. L. (1999) “Quantification of process parameters in a wood sanding operation” *Forest Product Journal* 49(5): 41-46.

Teuten EL, Saquing JM, Knappe DR. (July 2009) "Transport and release of chemicals from plastics to the environment and to wildlife". *Philos. Trans. R. Soc. Lond., B, Biol. Sci.* 364 (1526): 2027–45.

TIME Group, (2005) “Tıme Group company of surface roughness tester” (http://www.geneq.com).

TS 2471. (1976) “Determination of Humidity Rate for Physical and Mechanical Tests on Wood,” *TSE Standard*, Ankara.

TS 3891. (1983) “Adhesives polyvinyl acetate (for wood),” TSE *Standard*, Ankara.

TS 6956. (1989) “Surface Roughness-Terms-For Testing Surface Roughness Parameters,” *TSE Standard*, Ankara.

TS 930. (1989) “Tools Used in Testing Surface Roughness with Profile Method,” *TSE Standard*, Ankara.

TS 971. (1988) Rules of Parameters and Roughness Determination of Surface Roughness, *TSE Standard*, Ankara.

TSE EN 13887. (2007) “Yapısal Yapıştırıcılar-Metallerin ve Plastiklerin Yapışma Öncesi Yüzey Hazırlama Klavuzu,” *Turk Standartları Enstitüsü.*

Ulusoy H., (2011) “Bazı Ağaç Türü Odunlarının Anatomik Yapıları ve İşleme Koşullarının Yüzey Pürüzlülüğüne Etkisi,” Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü, *Doktora Tezi*, Trabzon.

Vick, C.B.,(1999) “Adhesive Bonding of Wood Materials, Wood Handbook-Wood as An Engineering Material,” *Department of Agriculture, Forest Service, Forest Products Laboratory*, V. 9.

Wålinder, M. E. P., and Gardner, D. J. (2002) "Acid–base characterization of wood and selected thermoplastics," *Journal of Adhesion Science and Technology* 16(12), 1625-1649.

Williams, R.S., Feist, W.C. (1999) “Water Repellents and Water Repellent Preservatives for Wood,” *USDA Forest Service, Forest Products Laboratory*, P.109.

Winfield P.H., Harris A.F., Hutchinson A.R. (2001) The use of flame ionisation technology to improve the wettability and adhesion properties of wood. *International Journal of Adhesion and Adhesives*, 21, pp. 107-114.

Wisconsin, M. (2010) “Centennial Edition, Wood Handbook,” *Wood as Engineer Material, Forest Laboratuary*, Chapter 10-12 US.

Wolfgang Spitzer, Design- u. Akustiksysteme e.U. A-4020 Linz, Händelstraße 40/6 **(**www.design-akustik.at**)** date of access: 12.01.2013

Yalıntırık F, Efe A. (1994) “Dendrology Course Book,” p. 102, İstanbul

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15. APPENDİX

Table 29: Direct measurement results of experiment samples weighed with 0.01 precision scales (gr).

	Wood*wood (oak) epoxy						Wood*wood (spruce) epoxy					
N	Drying measure	With adhesive	After presing	Room temp.	Hot cabin	the freezer	Drying measure	With adhesive	After presing	Room temp.	Hot cabin	the freezer
1	28.65	28.94	28.97	28.23	28.10	28.92	15.36	15.77	15.76	15.60	15,73	15.75
2	29.18	29.61	29.63	29.78	29.23	29.72	16.14	16.56	16.57	16.5	16,45	16.48
3	28.55	28.78	28.81	28.25	29.30	28.76	14.95	15.24	15.23	14.90	13.75	15.22
4	29.47	29.74	29.76	29.78	29.75	28.87	13.57	13.85	13.8	13.75	13.60	13.65
5	28.02	28.29	28.31	29.98	28.10	28.26	15.61	15.87	15.85	16.79	13.76	14.05
6	29.57	29.84	29.85	28.23	29.60	28.32	15.61	15.84	15.84	15.45	14.05	13.90
7	29.76	30.04	30.07	29.78	29.85	29.75	16.71	16.93	16.93	16.85	15.35	14.10
8	29.08	29.34	29.36	29.96	20.05	28.60	15.13	15.44	15.43	13.80	15.40	15.90
9	27.85	28.15	28.18	29.78	28.09	28.96	15.79	16.11	16.15	16.05	15.90	16.13
10	29.65	29.94	29.97	29.98	28.12	29.92	16.62	16.89	16.88	16.75	16.72	16.88
	Wood*PC (oak) epoxy						Wood*PC (spruce) epoxy					
1	31.26	31.49	31.49	31.46	30.85	31.63	25.6	25.98	25.98	25.95	26.61	24.62
2	31.63	31.98	31.95	30.15	31.98	31.35	24.63	24.96	24.98	25.53	24.96	25.13
3	31.32	31.52	31.52	31.48	31.70	31.62	25.72	26.09	26.09	25.09	26.61	26.07
4	30.43	30.81	30.81	30.50	30.88	31.62	24.5	24.89	24.89	24.84	24.96	25.13
5	31.38	31.64	31.64	31.47	31.98	31.35	24.01	24.36	24.37	25.09	24.36	26.07
6	30.61	30.85	30.84	30.81	30.90	31.62	24.32	24.63	24.64	24.84	26.61	24.62
7	30.21	30.54	30.55	30.55	30.88	31.35	24.7	25.15	25.15	25.09	24.96	25.13
8	31.27	31.62	31.63	30.81	31.10	31.62	25.18	25.55	25.55	25.53	24.36	24.62
9	31.16	31.36	31.36	30.55	30.99	31.35	24.68	25.12	25.12	25.09	24.36	25.13
10	30.42	30.74	30.75	31.45	30.81		26.22	26.63	26.63	24.90	26.61	26.07
	Wood*PMMA (oak) epoxy						Wood*PMMA (spruce) epoxy					
1	28.91	29.27	29.27	31.18	29.36	30.12	24.18	24.73	24.73	24.71	23.85	23.63
2	30	30.37	30.37	30.45	30.36	28.92	23.91	24.25	24.24	24.23	22.62	23.67
3	29.47	29.92	29.91	29.91	29.36	30.12	23.1	23.31	23.31	24.71	24.13	23.32
4	29.77	30.11	30.11	31.18	30.36	30.12	23.41	24.83	23.82	24.23	23.85	23.67
5	28.68	28.91	28.91	30.45	29.36	28.92	22.32	22.57	22.55	22.66	22.62	23.32
6	29.88	30.15	30.14	30.14	30.36	28.92	23.12	23.62	23.61	24.23	24.13	23.63
7	29.61	29.88	29.87	30.45	29.9	30.12	23.31	23.66	23.65	24.71	22.62	23.67
8	30.82	31.19	31.18	31.18	29.36	30.12	23.84	24.11	24.11	24.23	24.13	23.67
9	30.15	30.46	30.46	30.45	30.36	28.92	22.98	23.53	23.55	22.66	22.62	23.56
10	30.13	30,47	30.45	29.91	29.9	30.48	22.34	22.68	22.67	22.66	24.13	23.67

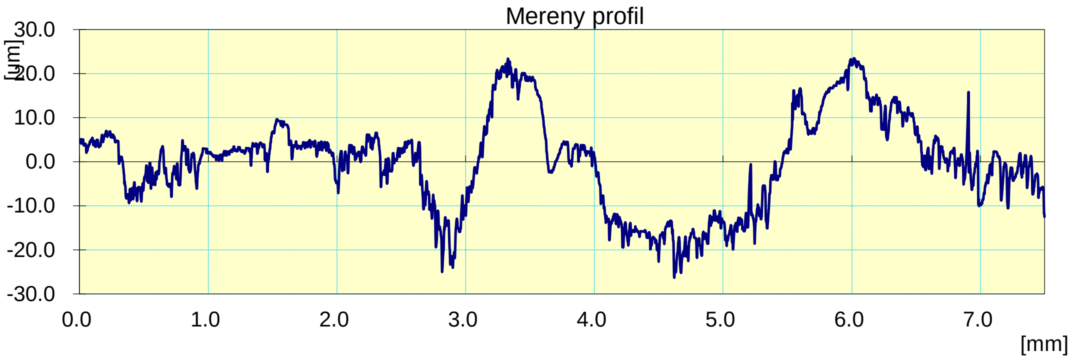

Figure 38: Example graph of surface roughness measurements done in the vertical direction to fibers for Cz spruce wood.

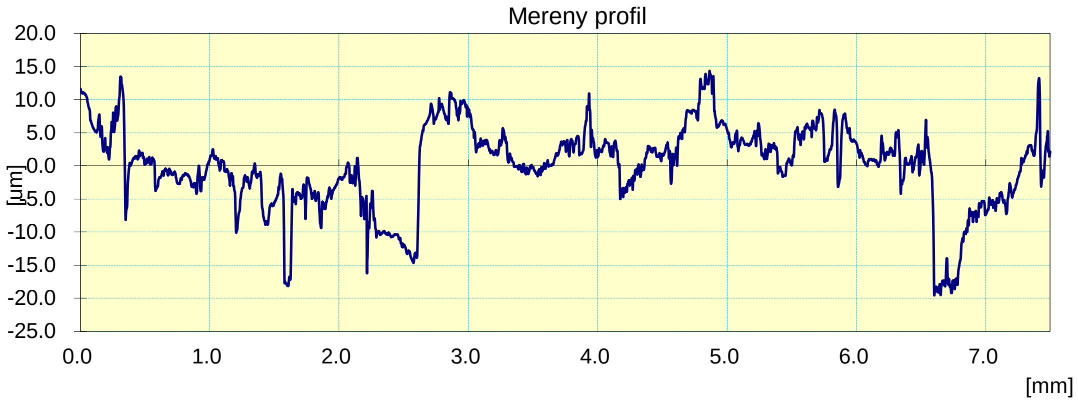

Figure 39: Example graph of surface roughness measurements done in the parallel direction to fibers for Cz spruce wood.

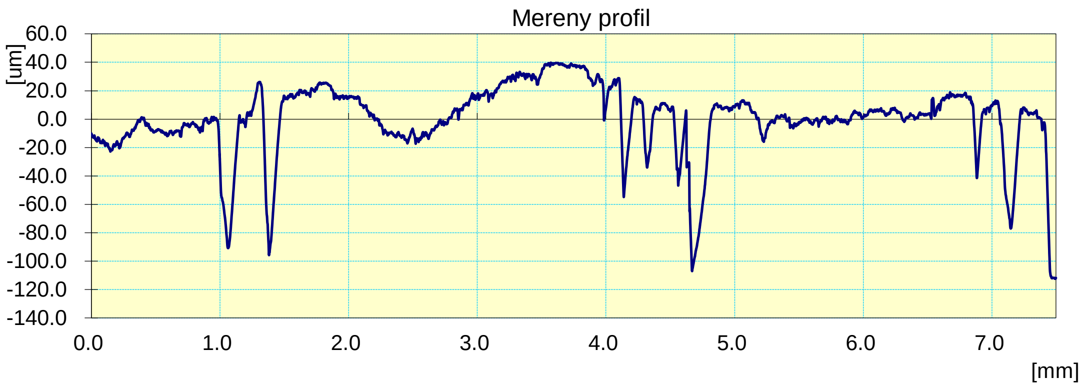

Figure 40: Example graph of surface roughness measurements done in the parallel direction to fibers for Cz oak wood.

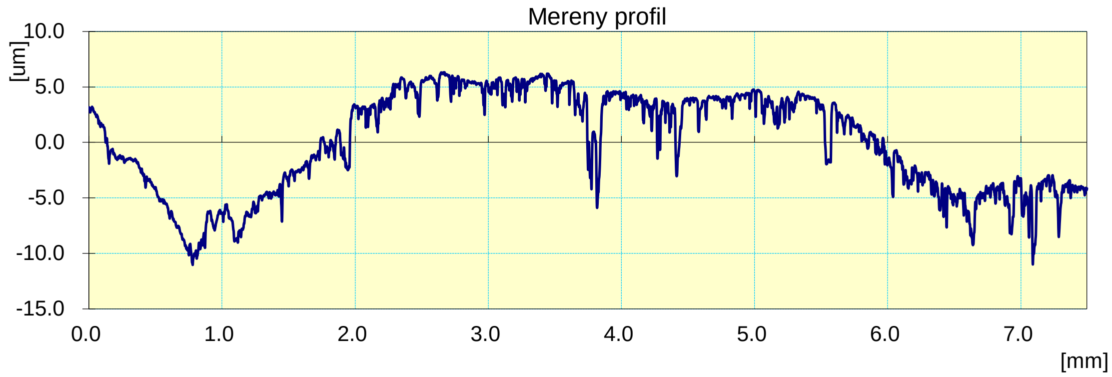

Figure 41: Example graph of surface roughness measurements done in the parallel direction to fibers for Cz oak wood

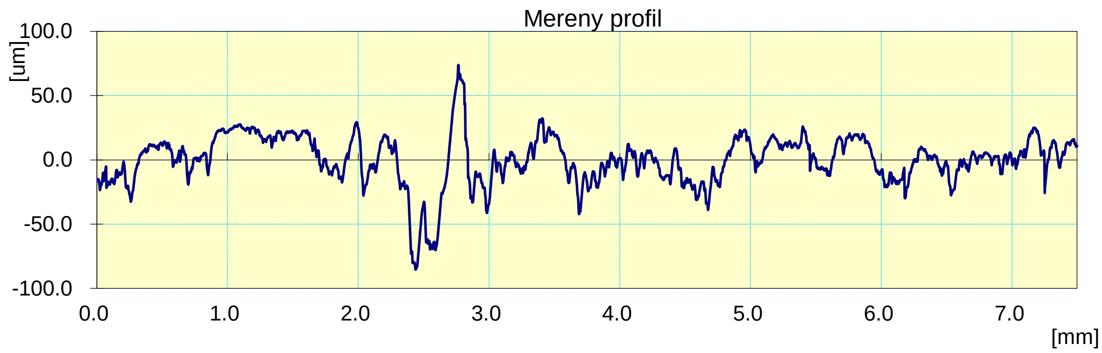

Figure 42: Example graph for surface roughness measurements done vertical to fibers for T chestnut wood.

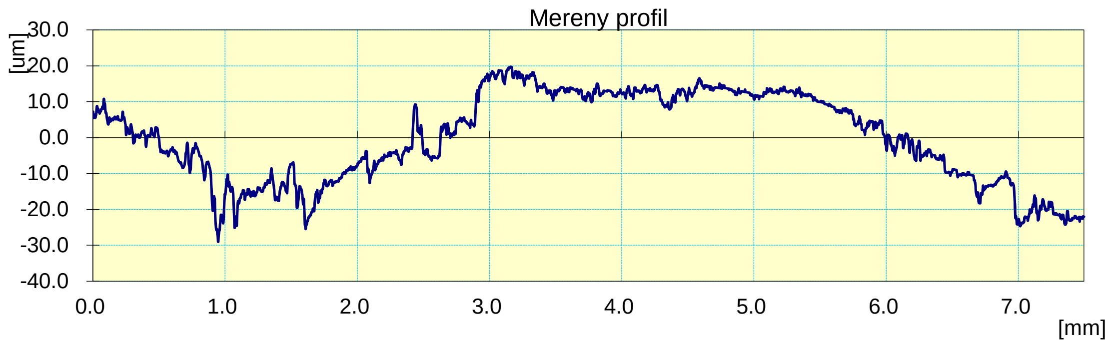

Figure 43: Example graph of surface roughness measurements done in the parallel direction to fibers for T Chestnut wood.

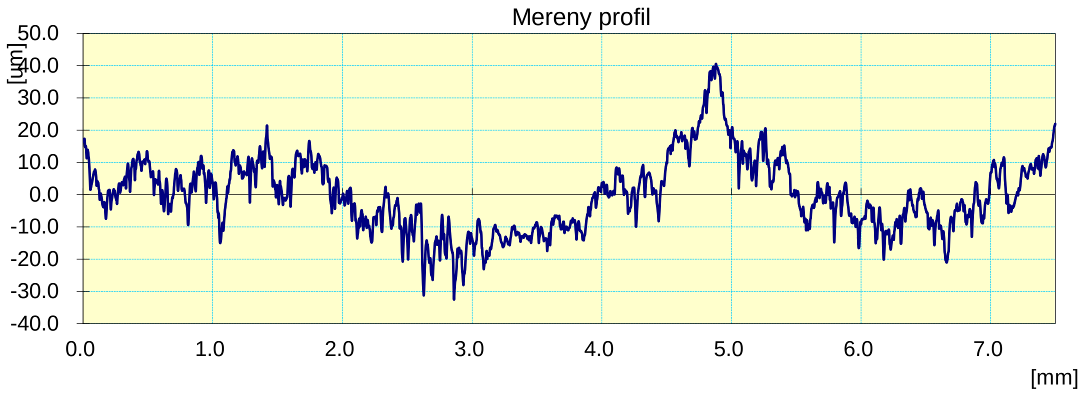

Figure 44: Example graph of surface roughness measurements done in the vertical direction to fibers for T spruce wood.

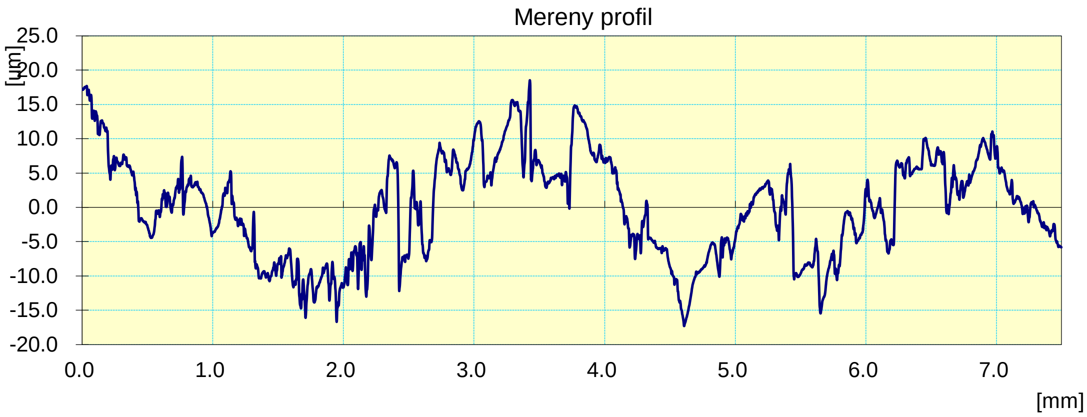

Figure 45: Example graph of surface roughness measurement done in the parallel direction to fibers

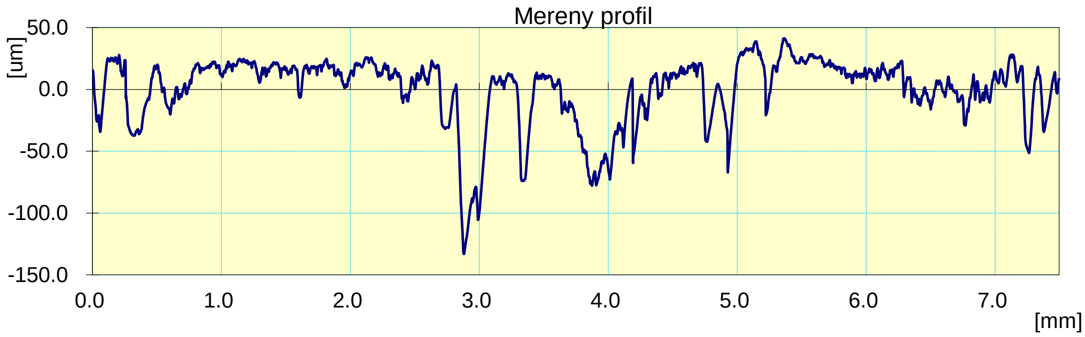

Figure 46: Example graph of surface roughness measurement done in the vertical direction to fibers for T oak wood

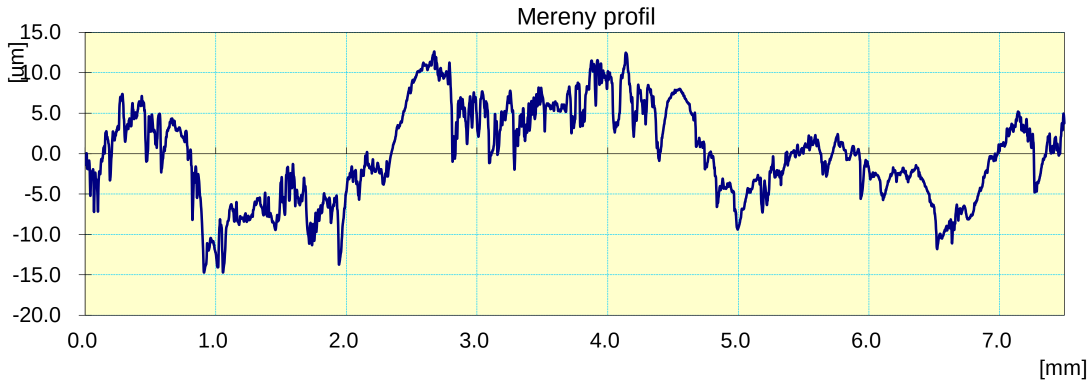

Figure 47: Example graph of surface roughness measurements done in the parallel direction to fibers for T oak wood

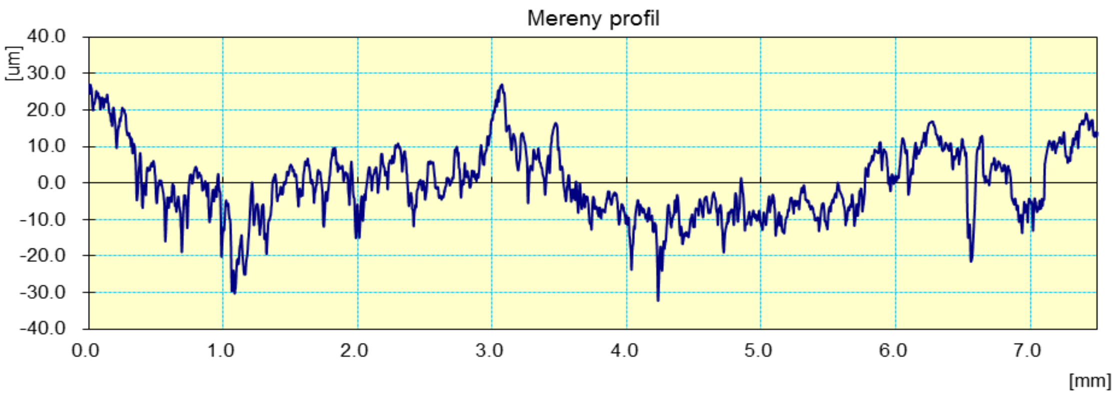

Figure 48: Example graph of surface roughness measurements done in the vertical direction to T cypress wood

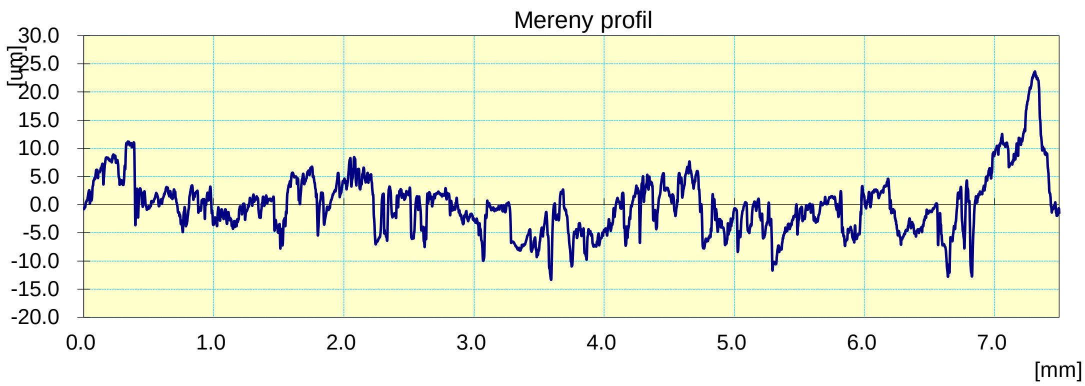

Figure 49: Example graph of surface roughness measurements done in the parallel direction to fibers for T cypress wood

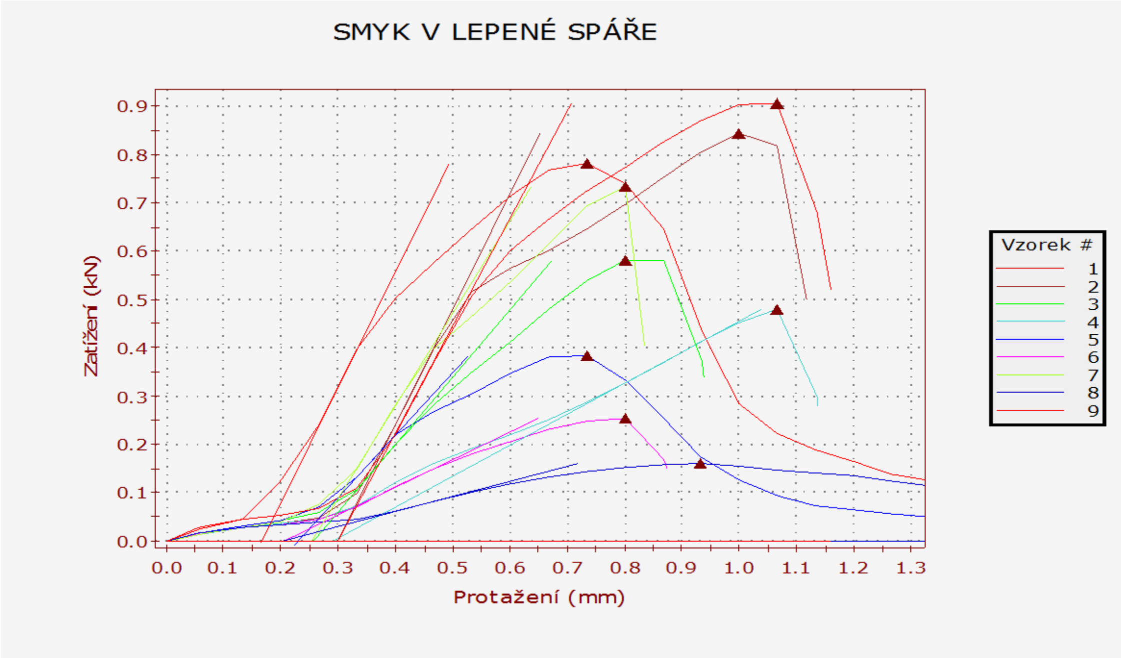

Figure 50: Example graph for wood*wood samples of C Oak wood which were bonded with solvent adhesive.

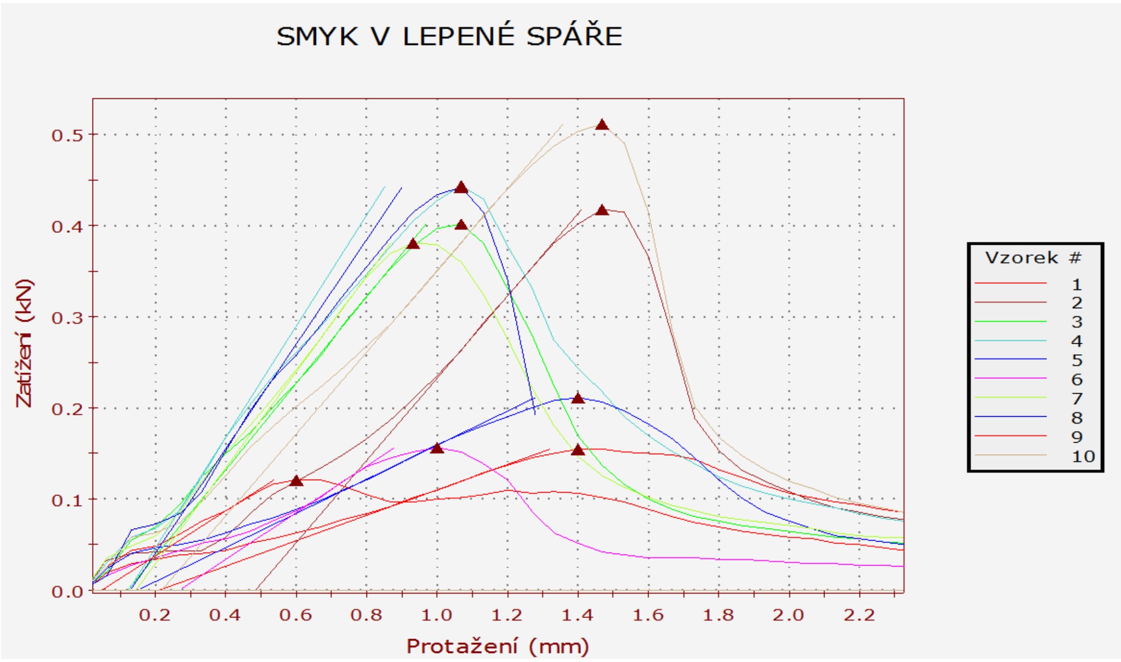

Figure 51: Example adhesion test graph for wood*PC samples of oak wood which were bonded with solvent adhesive

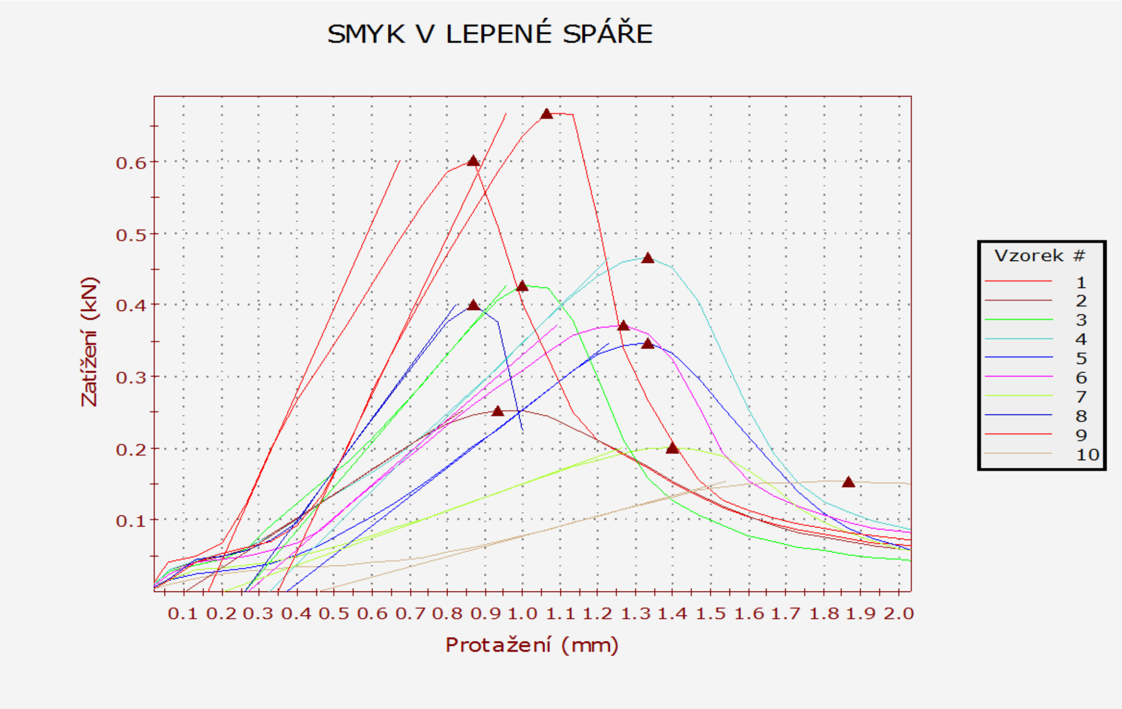

Figure 52: Example adhesion test graph for wood*PMMA samples of Oak wood bonded with solvent adhesive

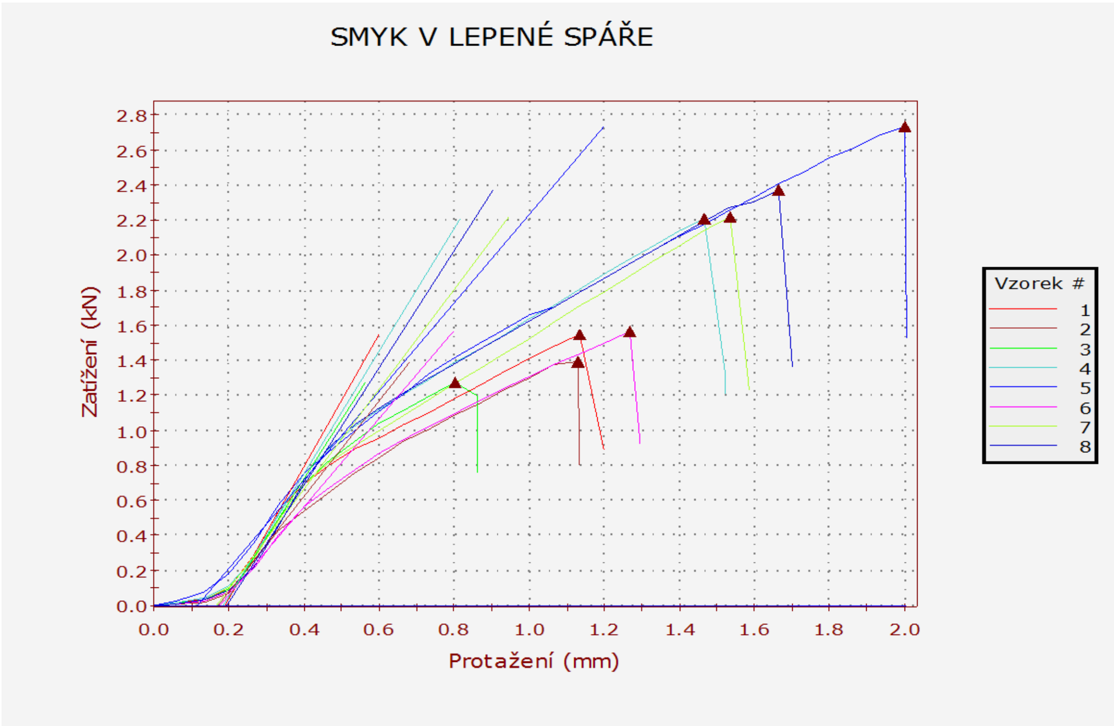

Figure 53: Example adhesion test graph for wood*wood samples of Cz Oak wood bonded with PUR adhesive

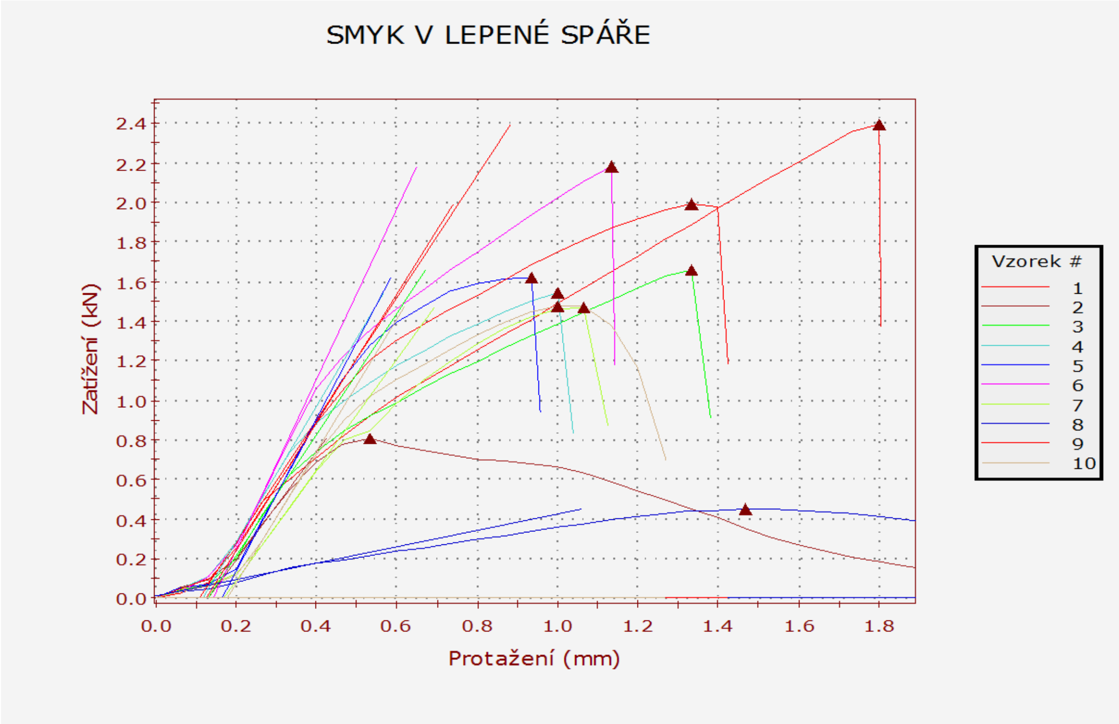

Figure 54: Example adhesion test graph for wood*wood samples of Cz Oak wood bonded with PVAc adhesive

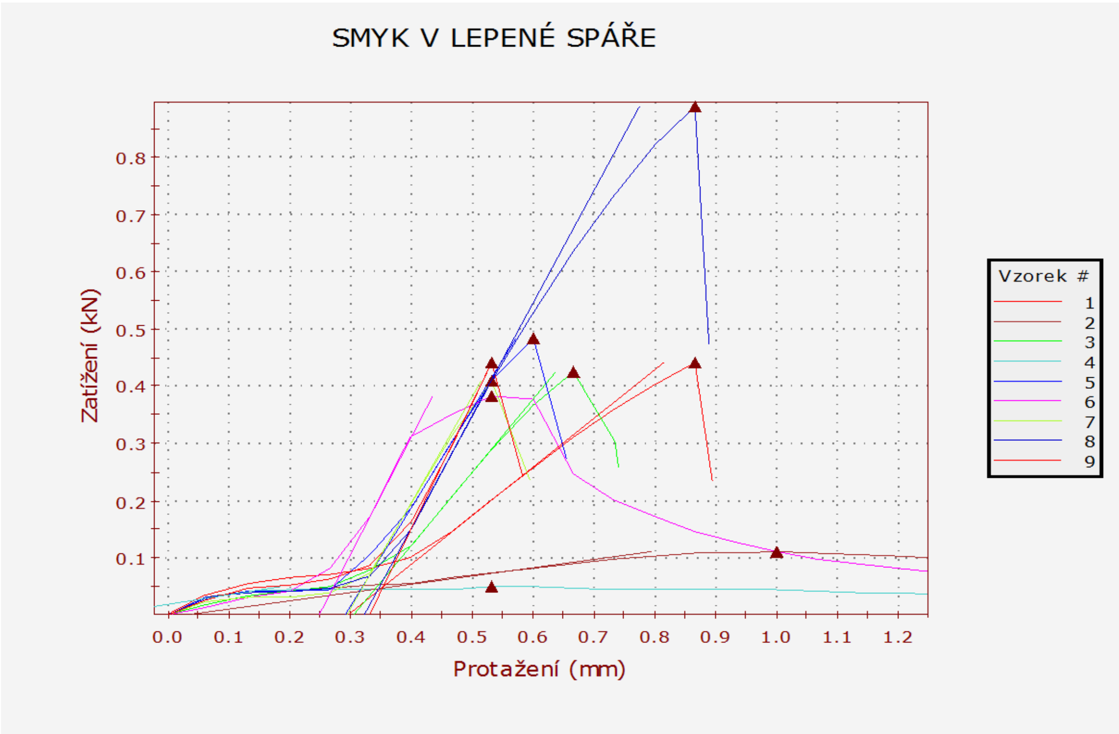

Figure 55: Example adhesion test graph for wood*PC samples of Cz Oak wood bonded wiyh PVAc adhesive

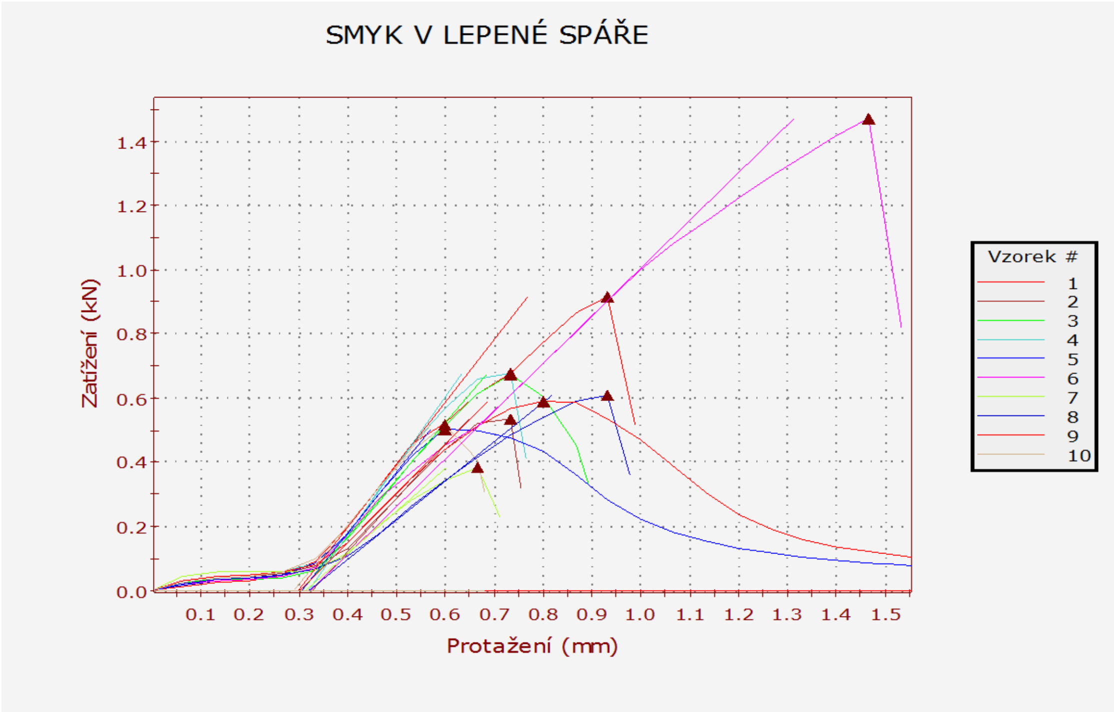

Figure 56: Example adhesion test graph for wood*PMMA samples of Cz Oak wood bonded with PVAc adhesive.

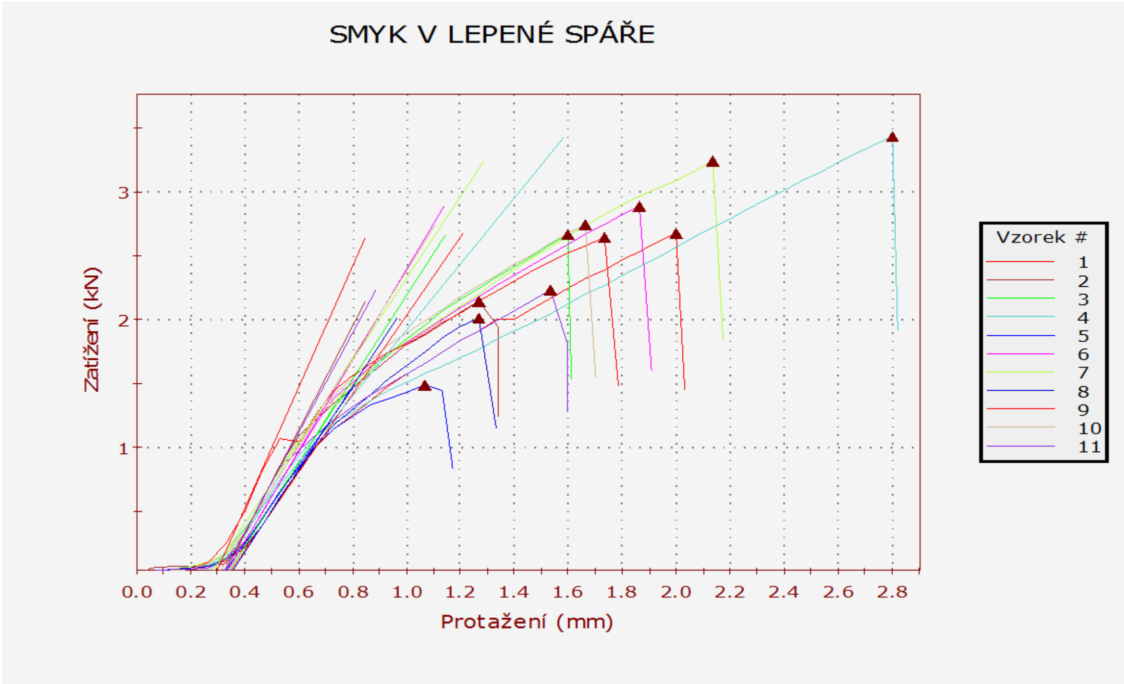

Figure 57: Example Adhesion test grapg for wood*wood samples of Cz Oak wood bonded with Epoxy adhesive

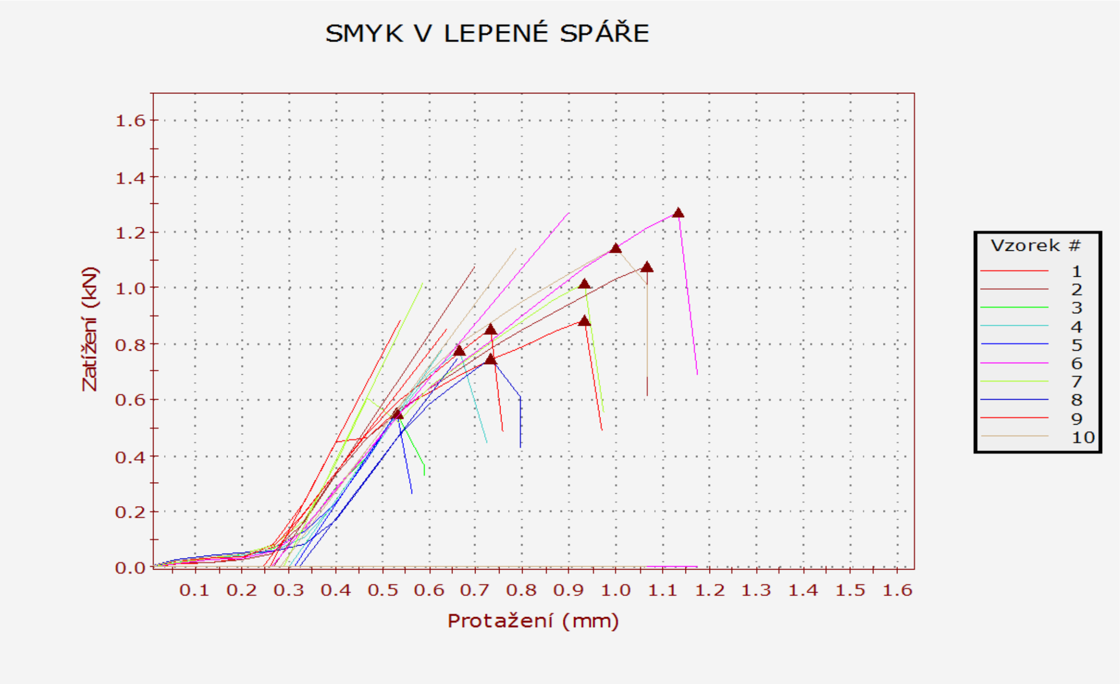

Figure 58: Example adhesion test graph for wood*PC samples of Cz Oak wood bonded with Epoxy adhesive

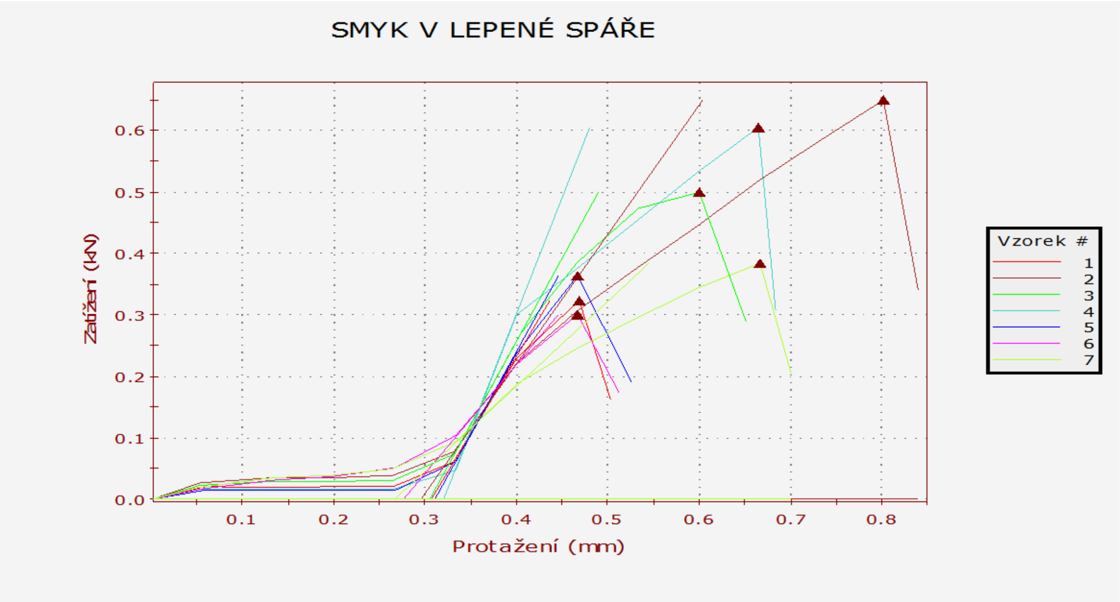

Figure 59: Example adhesion test graph for wood*PMMA samples of Cz Oak wood bonded with Epoxy adhesive

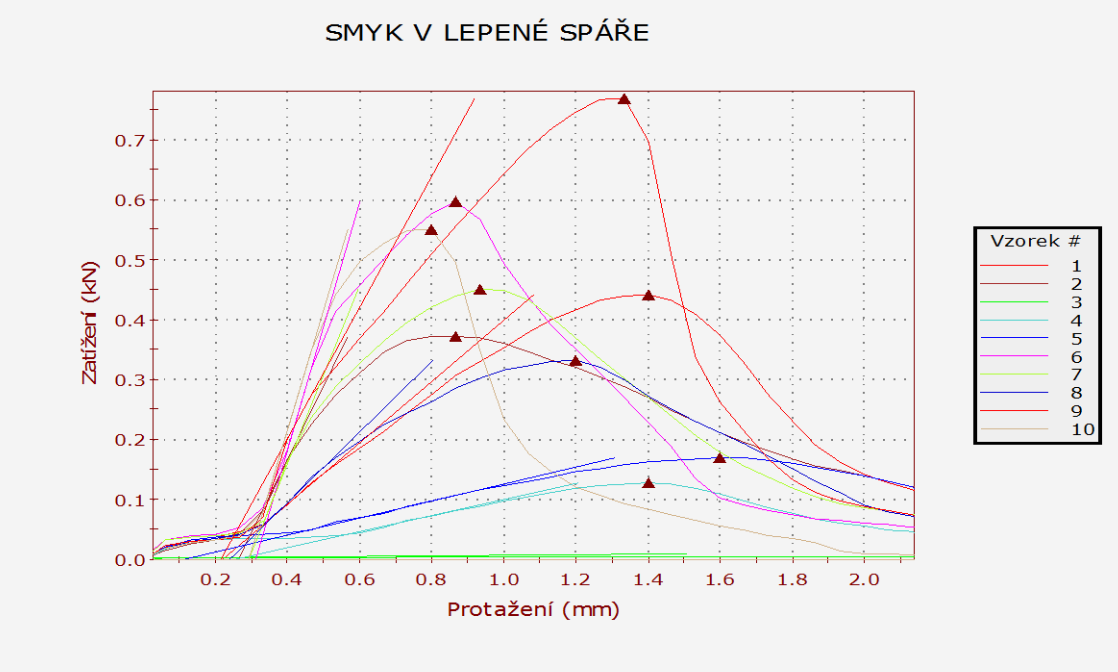

Figure 60: Example adhesion test for wood*wood samples of Cz Spruce wood bonded with Solvent adhesive.

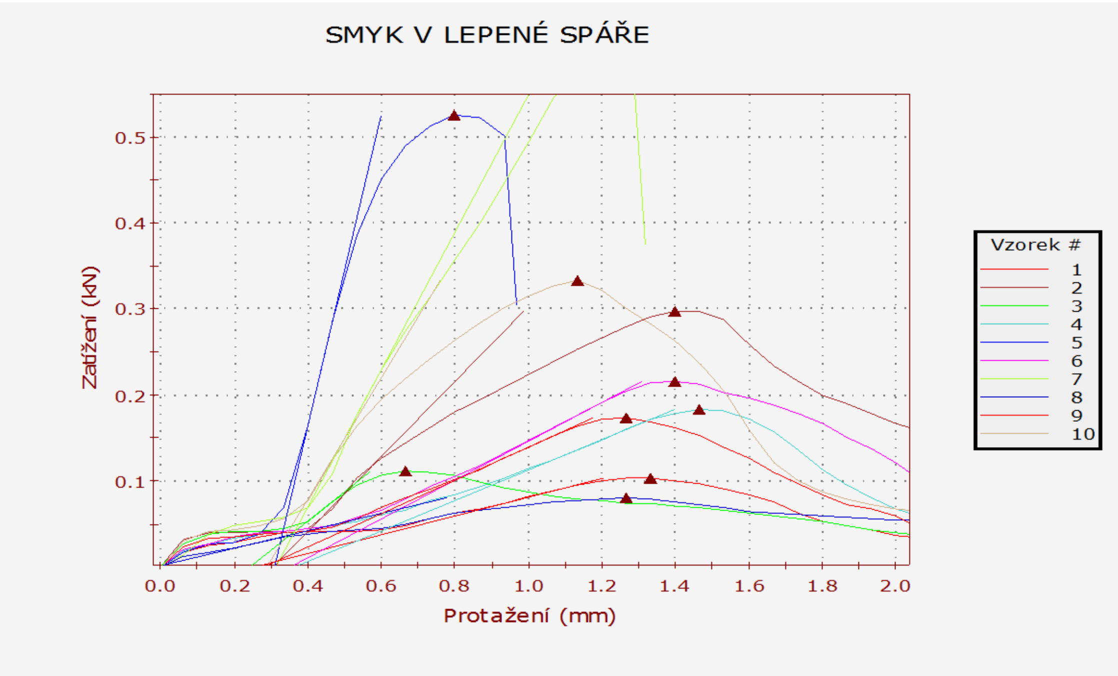

Figure 61: Example adhesion test graph for wood*PC samples of Cz Spruce wood bonded with Solvent adhesive

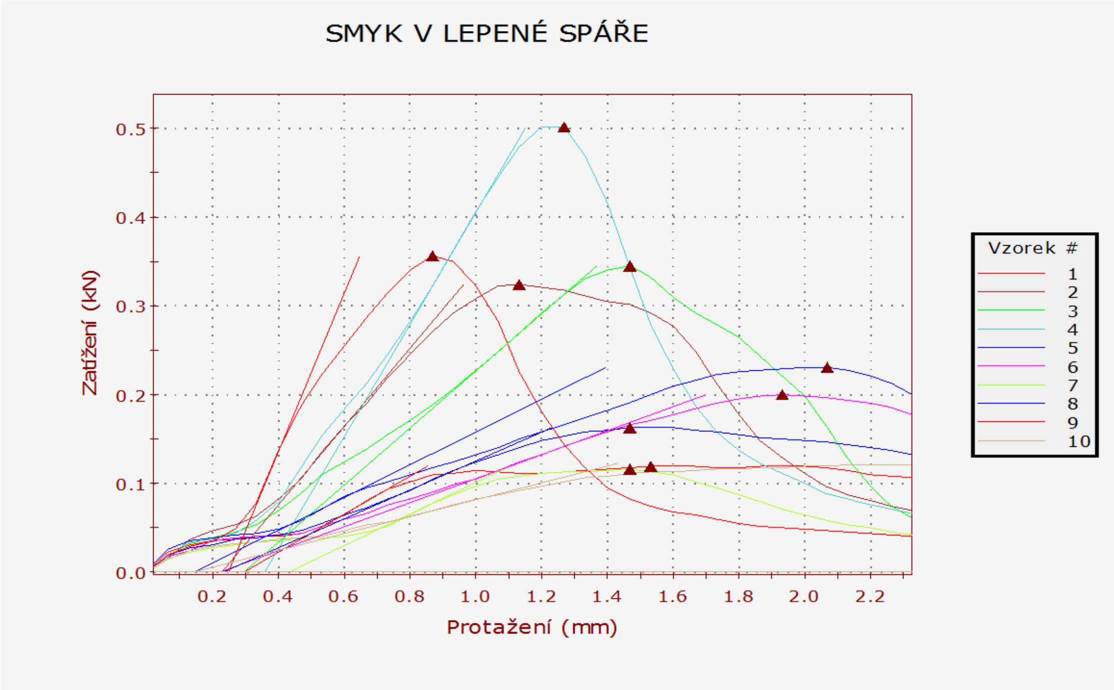

Figure 62: Example adhesion test graph for wood*PMMA samples of Cz Spruce wood bonded with Solvent adhesive.

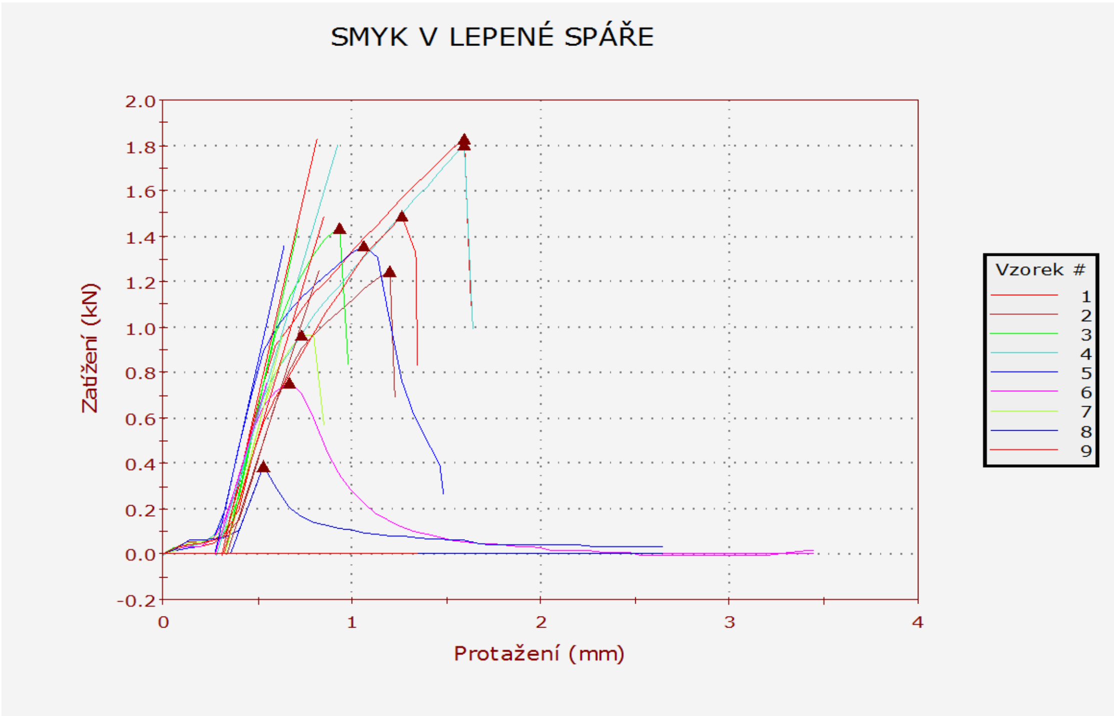

Figure 63: Example adhesion test graph for wood*wood samples of Cz Spruce wood bonded with Epoxy adhesive

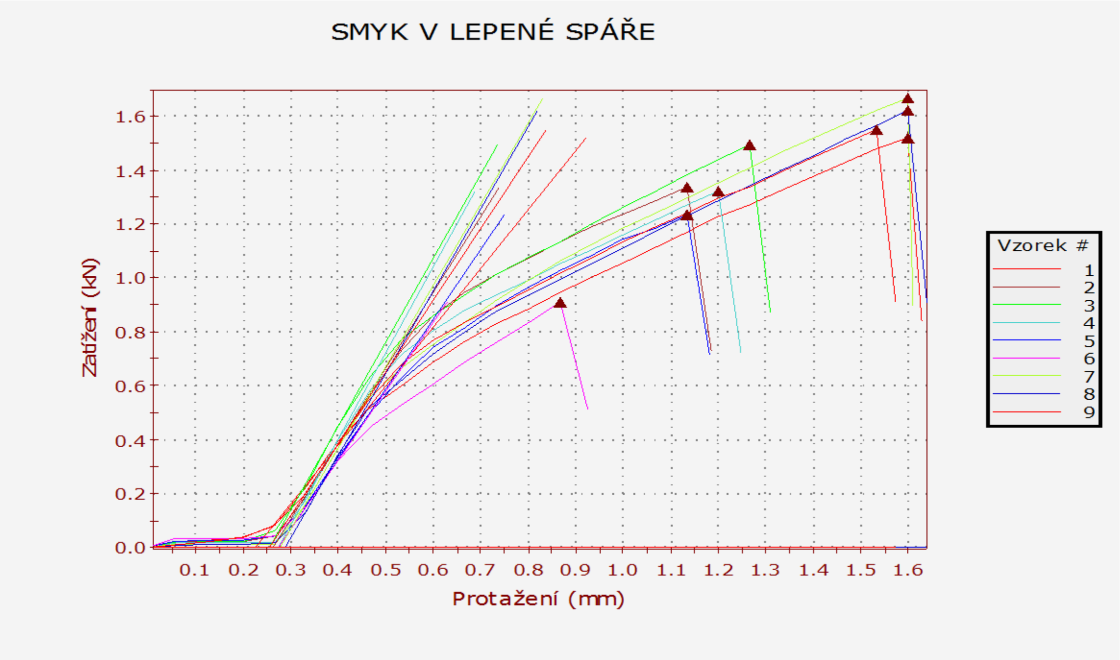

Figure 64: Example adhesion test graph for wood*PC samples of Cz Spruce wood bonded with Epoxy adhesive.

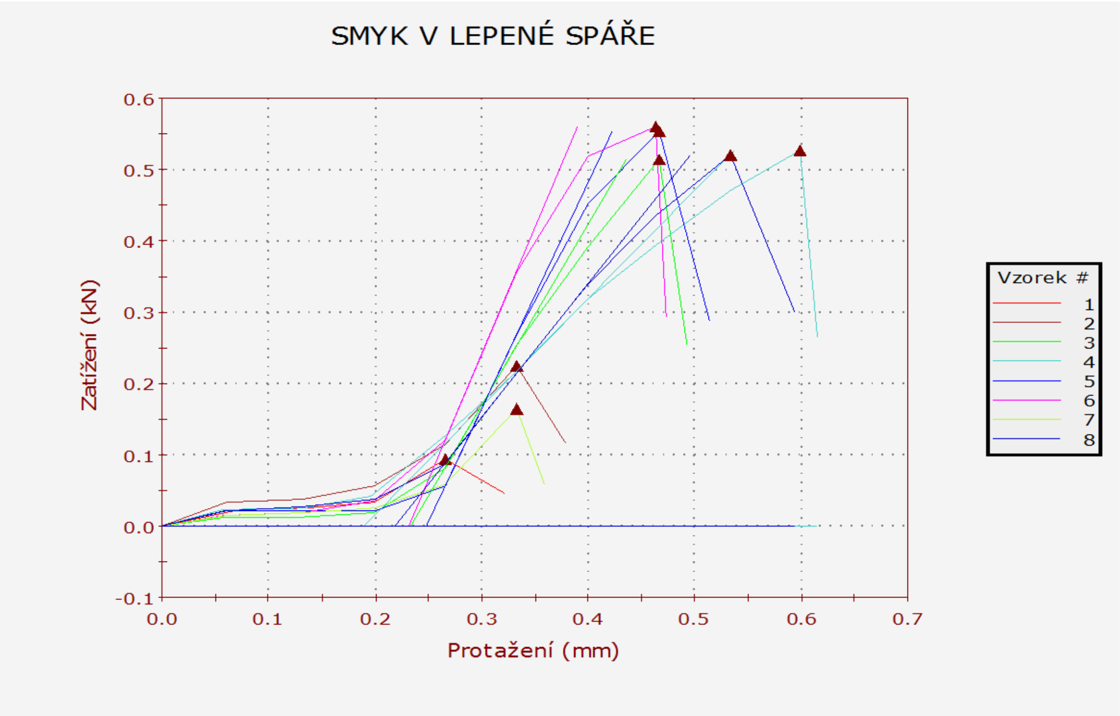

Figure 65: Example Adhesion test graph for wood*PMMA samples of Cz Spruce wood bonded with Epoxy adhesive

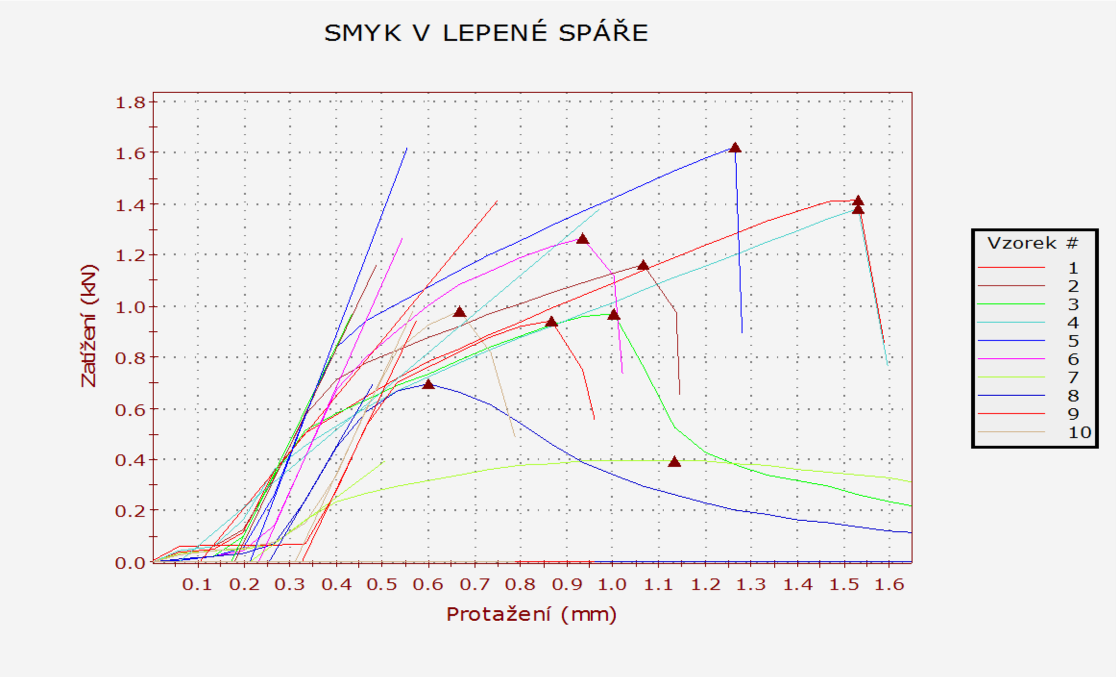

Figure 66: Example adhesion test graph for wood*wood samples of Cz Spruce wood bonded with PVAc adhesive.

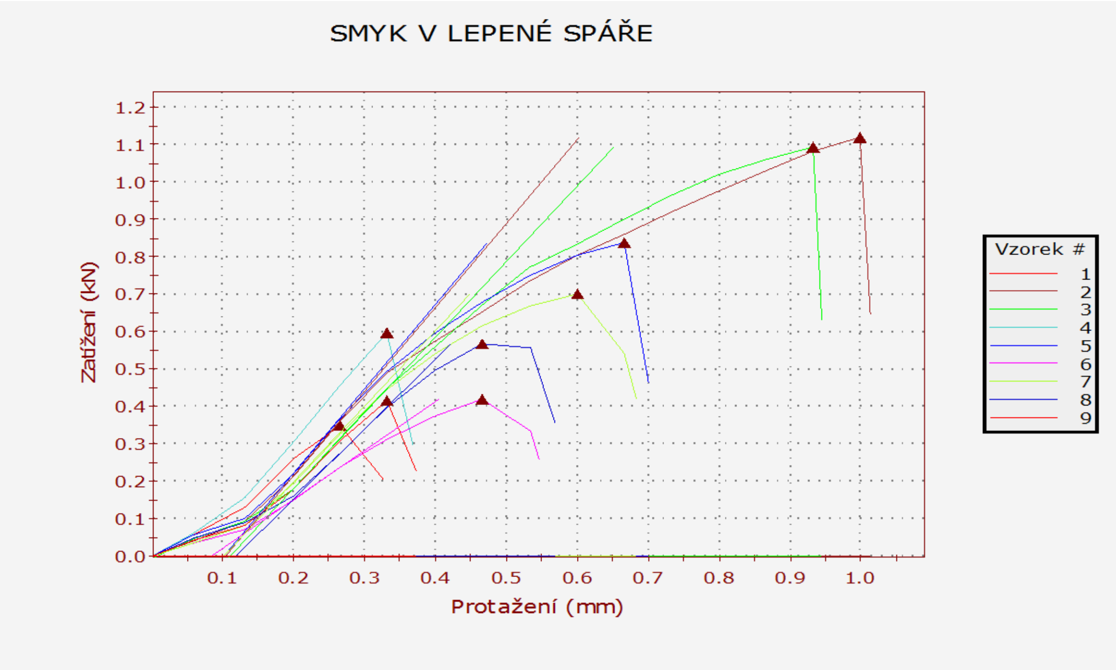

Figure 67: Example adhesion test graph for wood*PC samples of Cz Spruce wood bonded with PVAc adhesive

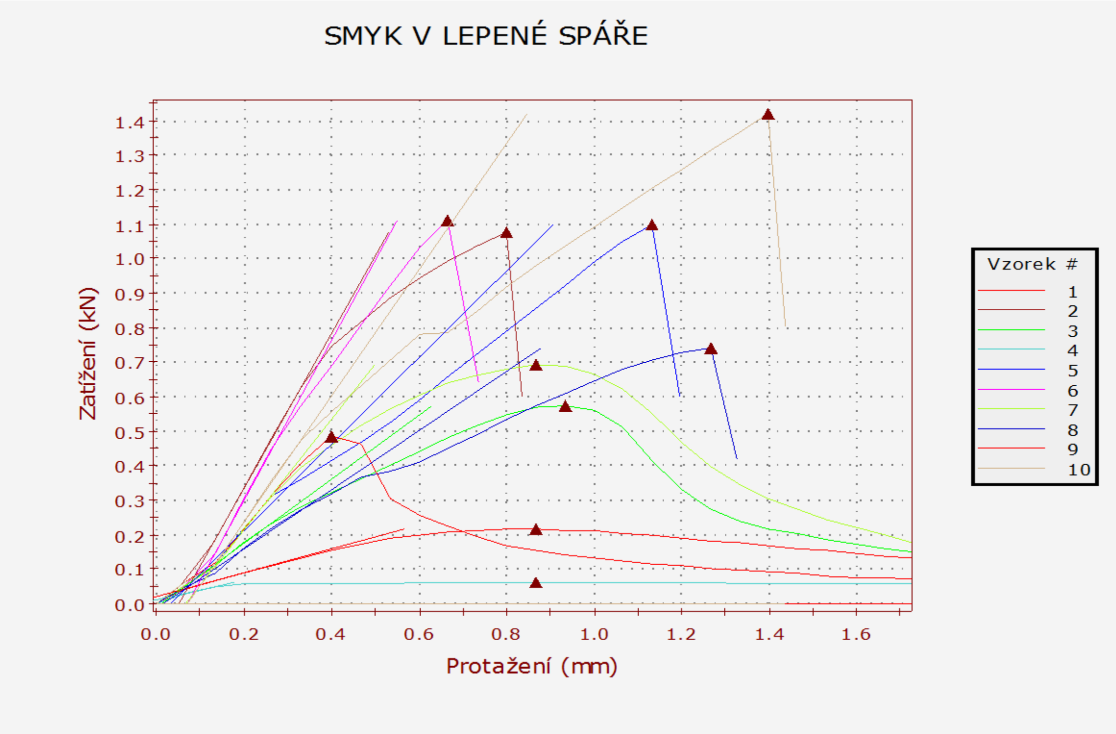

Figure 68: Example adhesion test graph for wood*PMMA samples of Cz Spruce wood bonded with PVAc adhesive