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A MINI REVIEW OF THE STUDIES ON MASSIVE WOOD MATERIALS MACHINING AND SURFACE QUALITY

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Abstract

The purpose of this study was to analyse and evaluate the studies on massive wood materials machining and surface quality. It has been observed that these studies were performed in order to determine optimal wood machining parameters for obtaining the best surface quality on various wood species. A variety of visual techniques and surface roughness measurement methods are used and studied to be developed in order to determine surface quality. Determining the most optimal processing conditions for all wood species used in the wood machining industry will be useful in terms of productivity, quality, and cost and so on.

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A MINI REVIEW OF THE STUDIES ON MASSIVE WOOD MATERIALS MACHINING AND SURFACE QUALITY

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1. Introduction

It has become a necessity to more efficiently treat and to use longer wood materials, which have been an irreplaceable raw material in the life of man throughout history, because of the constantly decreasing forests. The quality can be increased via determining the surface quality of the piece in accordance with the smoothness of the surfaces to be created via the treatment of the wooden materials with tools and machinery and eliminating the negative factors in the treatment phases. When treatment properties are mentioned, it is usually meant the performers obtained as a result of the planning, sanding, boring, shaping, mortising and turning of the wooden material to obtain smooth surfaces. Surface characteristics of wooden materials play an imported role in their use for final product manufacture.

Also, it is required that the surface of the wooden material is smooth for good surface treatment (Aras et al., 2007). In recent years, the esthetical aspect of surface smoothness is considered rather than the functional aspect. Surface smoothness has been covered within the quality criteria of the customer for evaluating wooden materials (Aslandogan, 2005).

It is clearly observed that obtaining quality and smooth surfaces and knowing the treatment properties is extremely important, especially for massive wooden material. Therefore, in this study, studies made regarding the treatment and surface quality of wooden materials from the past to the present are investigated and assessed.

2. The studies performed on massive wood materials machining and surface quality

Various studies have been made regarding the treatment and surface quality of wooden materials from the past to the present with different points of view.

Davis et al. (1954) reported that; the effect of certain machining factors on the quality of wood finish and on power consumed in operating a molder in their study. The five principal hardwoods (yellow birch, red gum, hard maple, white oak, yellow poplar) and the three principal softwoods (Douglas-fir, ponderosa pine, southern yellow pine) were studied. These tests were performed two types of cutter materials (high-speed steel and carbide), five cutter head speeds (3600, 4800, 5400, 6000, 7200 revolutions per minute), two moisture contents (6% and 20%), five feed-speed combinations (60, 80, 90, 100, 120 feet per minute), and five cutting angles (0^o, 10^o, 20^o, 30^o, 40^o). That results obtained from the study as follows; if the quality of finish is poor at 8 or 10 knife cuts per inch, adjust the feed rate or cutterhead speed to get at least 16 knife cuts, When the knives are jointed in the head, keep a close watch on the lands, or jointed portion of the edges. The lands form part of the cutting circle and have no clearance. Finishing cut on the face of the work should be made as much as shallow. If the amount of chipped grain is excessive, the cutting angle of the knives reduces by 10^o at least. For minimum raised or fuzzy grain, drier lumber was used just as far as practicable.

In his work titled “Three “musts” for good machining”, Davis (1959) stated that good machine work has three basic requirements: a machine in good mechanical condition with cutting tools reasonable sharp, a machine properly adjusted and operated, wood properly seasoned and selected to meet the needs of the job. In this study are given detailed information about knife angles, depth of cut, moisture content, rate of growth and density.

In his study Davis (1960) made studies on the machining properties of ponderosa pine and Douglas fir and their density and growth rate. According to the results of the study, both the number of rings per inch and the specific gravity of a given sample of ponderosa pine or Douglas-fir affect its machining properties to the degree that is highly significant, at least for the more exacting uses. In ponderosa pine and Douglas-fir, the number of rings per inch has more effect on the machining properties than does specific gravity.

His study titled “Surface-texture measurements for quality and production control”, Stumbo (1960) compared surface textures of sawn, planed, molded and sanded surfaces; presented surface-profile indices and suggested their use for quality control and waste prevention. According to the study, the surface texture must be determined and analysed to control the surface of a wood product.

Davis (1962) gave short information about fuzzy grain in planning operations. He classified the factors occurring fuzzy grain such as cutter sharpness, moisture content, cutting angles, grinding bevels, excessive heel build-up, tension wood, depth of cut, feed rate, peripheral speed.

Stumbo (1963) said that the stylus tracer technique is the most accurate method in measurement and analysis of surface texture of wood.

Cantin (1965) determined the machining properties of a number of sixteen Eastern Canadian Woods. The operations were as follows: turning, planning, boring, mortising and shaping. The ten hardwood species studied were: white ash, large-tooth aspen, trembling aspen, basswood, beech, white birch, yellow birch, hard maple, red maple and red oak. The six softwood species were: balsam fir, black spruce, white spruce, jack pine, red pine and white pine. In planning, seven cuts 1.6 mm deep, under different sets of conditions covering four cutting angles (15^o, 20^o, 25^o, 30^o) and four numbers of marks per inch (8,12,16,20) were performed. According to the study results, in turning, the best turnings were usually obtained, being those with relatively high density and many rings per inch.

Peters et al. (1966) made studies to determine some machining properties (planning, shaping, turning, boring, and mortising) of two wood species grown in Hawaii Molucca albizzia and Nepal alder. According to the result of the study, best results were obtained when the wood materials were planned with a 10-degree cutting angle. Both Molucca albizzia and Nepal alder should be suitable for core stock, provided sufficient straight-grained material is available. Nepal alder could probably be used for some medium-value furniture parts.

A great amount of effort has been devoted to measuring wood surfaces. With few exceptions, each investigator used a different measuring method. Three methods are predominant - visual, light sectioning, and stylus tracing – but no system has been completely satisfactory (Stumbo, 1963).

In his work titled "Cross - grain knife planning hard maple produces high-quality surfaces and flakes" Steward (1970) investigated the surface roughness of some Hard maple panels from tree materials machining in the planning machine. The panels were planed (cross and parallel to grain) at 36 prescribed machining combinations of four rake angles (10, 20, 30 and 45 degrees), three depths of cut (0,8 mm, 1,6 mm, 3,2 mm), and three feed rates (10, 20 and 30) knife marks per 2,54 cm. According to the study results, maximum surface roughness was less for planning cross grain than for planning parallel to the grain, but average surface roughness was about the same for both methods.

In their study titled "Measuring wood surface smoothness: A proposed method" Peters and Mergen (1971), developed a stylus tracking device for the measurement of a wood surface. As a result, a precise method for measuring wood smoothness would be useful in laboratory development and manufacturing quality control. Tests showed that it had sufficient range and sensitivity to show wood anatomy as well as 0,25 inch–deep roughness. The complete system, included a head assembly, balancing network, amplifier, calibrating networks, and recorder, detected many degrees of roughness in trails.

In their study titled "Air-flow method measures lumber surface roughness" Porter et al. (1971) described a simple inexpensive device. A practical, inexpensive device was designed and tested for the measurement of relative surface roughness of circular-sawn and band sawn lumber. The instrument measures the quantity of air required to maintain a constant pressure differential between an inner pocket reservoir placed over the wood surface and the atmosphere. The device should prove helpful to lumber producers interested in improving the surface of their sawn lumber.

In their study titled "Boring deep holes in Southern pine", Woodson et al. (1972) investigated the boring operation in massive wooden material. Southern pine specimens and two bit types (double-spur, double-twist machine bit; ship auger) were used. According to the results of the experiments, in boring along the grain, the ship auger made better holes than the machine bit when the wood was dry; in wet wood hole quality didn't differ between bit types. When boring across the grain, the machine bit made better holes in both wet and dry wood.

In his work titled "Machining properties of wood", Kurtoglu (1981) stated that when machining properties are mentioned, it is usually meant the performers obtained as a result of the planning, sanding, boring, shaping, mortising and turning of the wooden material in order to obtain smooth surfaces and gave brief explanations regarding these operations. He explained and classified the errors occurring in the machining of the wood as raised grain, fuzzy grain, chipped grain, chip marks. He itemized the conditions necessary for a good treatment, made an explanation regarding the force requirement in treatment activity, and stated that the force requirement depended on specific gravity, moisture content of the wood, cutting angle, feed speed, speed of the cutter head, and cutter types. At the end of the work, he explained the factors to be considered to avoid the errors occurring during the treatment of wood.

In his work titled "Characterizing the roughness of southern pine veneer surfaces", Faust et al. (1986) used Southern pine veneer samples. A stylus tracing technique was used to obtain surface profiles. Veneer samples were visually classified into three roughness classes (rough, intermediate, and smooth).

Five indexes were calculated after each of eight levels of roughness grade had been removed from the profiles. The five indexes were evaluated by an analysis of variance for their ability to distinguish the three roughness classes and tight and loose veneer sides.

Faust et al. (1986); made a study to determine the effect of veneer surface roughness on glue bond quality in Southern pine plywood. According to results of the study confirm the undesirable effects of veneer roughness on Southern pine plywood glue bond quality, especially; when measured by industry standards. In addition, when conditions for over penetration exists (short assembly time and low veneer temperature), rougher glue lines will further reduce glue bond quality in terms of wood failure. The image analysis technique appears to be adequate to measure veneer roughness at production speed (100 fpm) within some constraints (Faust, 1987).

In their study titled “Effect of tooth geometry on surface quality of sawn timber in band saws”, Ors et al., (1991) investigate the effect of the tooth geometry of band-saws on the surface quality of timber. They established the most suitable tooth profile through sawing Scotch pine (*Pinus silvestris* L.) lumbers according to the tooth geometries prepared in 4 different groups for band-saws. According to the study results, the best surfaces quality is established on lumbers sawed with saws with PV tooth (skewed tooth) profile with all the teeth smashed and equalized. This was followed by lumbers obtained with saws with four PV teeth smashed and equalized and one tooth left smooth, with two PV teeth crossed, and one tooth left smooth, and four PV teeth crossed and one tooth left smooth. The worst surface has occurred in timbers produced with saws having NV (sharp tooth) crossed teeth due to the breaking of the teeth. or the sawing process carried out with saws with crossed teeth, it was stated that the surface quality gradually deteriorated as a function time. This was caused by the deterioration of the crosses depending on the increasing number of lumbers sawn the deviations in the tooth geometry.

In the master’s thesis titled “The effect of feed speeds and planning machines to surfaces quality in wood industry”, Gurtekin (1996) investigated the effect of the cutting and moving speed of the wood planning machines used in the woodworking industry on the smoothness of the planed wooden surface and on the quality. Woods of oriental beech and larch tree have been used as experiment samples. The investigation has been carried out based on defects such as surface smoothness, raggedness, blade mark, burn formation, etc., as quality factors. At the end of the study, it was concluded that increasing the number of plates and the cutting speed and decreasing the feeding speed improved the wooden surface quality.

In the study titled “Faults occurring in the machining of wooden material”, Kurtoglu (1996) stated that defects such as raised grain, fuzzy grain, chipped grain, chip marks in the machining of massive wooden material. In the study, such defects occurring in the treatment of wooden material have been individually explained, and the reasons for occurrence, on which tree types they are more generally encountered, and the precautions to be taken against those are indicated.

In the master’s thesis titled “The effects of circular saws on surface roughness at wooden materials”, Demirci (1998) compared the surface roughness after the wooden materials have been sawn with circular saws. In his study, he determined the surface roughness value on samples prepared from oriental beech, Scotch pine, durmast oak and acacia based on the tree type, cutting direction, a number of teeth, and feeding speed. In the results of the study, Scotch pine wood gave the smoothest surface and oak wood the roughest surface under the same trial conditions. The smoothest surface was obtained with the circular saw with 24 teeth at a 5 m/min feeding speed at radial directions. Also, radial cross-sections, give smoother surfaces in comparison to tangential cross actions; surface roughness increases with the increasing feeding speed; the smoothest surface was obtained with a circular saw with 24 teeth at radial directions; the roughest surface was obtained with a circular saw with 40 teeth at the radial direction; and no significant difference was observed on the oak wood amongst saws with regards to surface roughness.

Gurleyen (1998) made studies to compare the surface smoothness of massive wooden materials after machining with cutters in his master’s thesis titled “Comparison of surface smoothness in the materials of solid wood used in the furniture”. Tree type of oriental beech, Scotch pine, oak and acacia were used in his experiments. According to the results of the experiments, the smoothest surface was obtained from Scotch pine wood and the most roughest surface from oak; with regards to interaction of tree types and blade numbers, the smoothest surface was obtained from acacia wood in 4-blade planning, and the roughest surface from oak wood with 2-blade cutter; smoother surfaces are obtained in tangential cross-sections compared to radial cross-sections and in 4-blade planning compared to 2-cutters planning; the direction and type of the cutters were found statistically insignificant.

In their study, Williams et al. (1998) determined machining and related mechanical properties of 15 British Columbia wood species. Within this scope, they carried out turning, planning, sanding, boring, mortising and shaping. The machining tests were conducted according to ASTM D 1666-87. The surface quality of each sample tested was examined both visually and by touch. The most common defects were raised grain, fuzzy grain, chip marks, crushed grain and rough end grain. The results of the six machining tests are summarized in a table.

Korkut (1999) intended to establish the parameters providing quality of the optimum surfaces through theoretical and applied studies to determine the factors affecting the lumber surface quality in his master's thesis titled "Studies on the improvement of surface quality in lumber production". In this study, Scotch pine logs were used; sawdust weight method was used to determine the surface roughness; and the effects of log humidity amount, usage time of saw plates, type of teeth, amount of crosses, and feed speed on lumber surface roughness were evaluated. According to the results of the study, it was established that lumber surface roughness increased with the increasing log humidity, that no significant increases occur during the use of stellite saw plate for 0 and 2.30 hours, that saw plates with PV tooth type give smoother lumber surfaces compared to saw plates with NV tooth type, that there is no significant difference between the surface smoothness values obtained from lumber manufacture with saws having one-sided cross amounts of 0,8 ± 0,05 mm and 0,6 ± 0,05 mm, and that the lumber surface smoothness increases with increasing feed speed.

Lihra et al. (1999) intended to determine the manufacturing properties of nine Eastern Canadian softwood species (jack pine, red pine, Eastern white pine, black spruce, white spruce, balsam fir, tamarack, Eastern white cedar, Eastern hemlock), five Eastern Canadian hardwood species (yellow birch, white birch, sugar maple, red maple, trembling aspen) and three European and Asian species (Scotch pine and Norway spruce from Europe and sugi from Asia). They carried out planning, sanding, boring, mortising, shaping, turning, screw withdrawal and nail withdrawal properties. According to the study; Red pine showed the best average performance of all tested species showing no major defects in any of the performed machining tests. Yellow birch and sugar maple were the best performing hardwoods. Trembling aspen reached a high average score but performed poorly in the sanding test due to fuzzy grain. Black spruce and Eastern white pine showed good and uniform machining qualities in all tests.

Malkocoglu et al., (1999) referred to the importance of surface roughness and made definitions regarding surface roughness and roughness in their collected work titled "Historical development of surface roughness studies". They stated that the surface roughness studies first started in the metal industry and explained their historical development starting from 1930. After mentioning the formation of surface roughness in wooden material, factors affecting the surface roughness, and the classes of surface roughness (texture), they gave information about the importance of surface roughness. They stated that surface roughness evaluations could be carried out qualitatively and quantitatively. Each of the method had advantages and disadvantages such, as measurement speed, sensitivity, and giving accurate results.

In their study titled "The effect of planning and sanding on surface roughness of massive wood", Ors et al., (1999) investigated the effects of wood type, cutting direction, number of cutters, grit sizes, and feeding speeds on surface roughness of planed and sanded massive wooden materials, using oriental beech and Scotch pine. In measuring the surfaces roughness, they used a stylus tracing technique. As a result, smoother surfaces were obtained in oriental beech compared to Scotch pine after planning and sanding processes; surface roughness values were found to be lower in both tree types in the direction tangential to the annual rings compared to the radial direction; with regards to interaction of tree type and number of plates in planning, the smoothest surface was obtained in oriental beach with 4-cutter heads planning and the roughest surface in Scotch pine with 2-cutter heads planning; with regards to interaction of tree types and grit sizes, the smoothest surfaces were obtained from oriental beech with 120 grit sandpaper; with regards to interactions of tree types and cutting direction, number of cutters (planning), and grit sizes (sanding), the average smallest surface roughness value was obtained in oriental beech in a direction tangential to annual rings with 4-cutter head planning and number 120 grit sandpaper; and the surface roughness values were found to be higher in the feeding speed of 9 m/min compared to 5 m/min for planning and 20 m/min compared to 5 m/min for sanding.

In their study titled "The investigation on the improvement of the surface quality in sawn timber production", Kantay et al. (1999) intended to determine some significant factors affecting surface roughness in lumber production and establish the most suitable values related to such factors for optimum surface quality. As a result, they determined that surface roughness does not change with increasing log moisture content over the fiber saturation point, that no significant increases occur during the use of stellite saw plate for 2.5 hours, that saw plates with PV tooth type (curved tooth) give smoother lumber surfaces compared to saw plates with NV tooth type (sharp tooth), that there is no significant difference between the surface smoothness values obtained from lumber manufacture with saws having one-sided cross amounts of 0,8 ± 0,05 mm and 0,6 ± 0,05 mm, and that the lumber surface smoothness increases with increasing feed speed.

The planning, shaping, boring, turning and mortising properties of white spruce wood from a provenance trial and a natural stand were evaluated by Hernandez et al. (2001). This research showed that wood of white spruce grown in plantations has a good performance for planning, shaping and boring processes and poor performance for turning and mortising processes. The best planning condition was obtained at a 15^o rake angle and 20 knife marks per inch of feed speed.

In their study titled "Investigation of surface roughness of sliced walnut and beech veneers produced in Turkey", Kantay et al. (2001) compared the surface roughness values of sliced veneer plates obtained from walnut and beech from Turkey with the surface roughness values of veneers produced in other countries. In measuring the surfaces roughness, they used a stylus tracing technique. The average roughness values of the veneer plates obtained from factories were found to be R_a= 8,95 µm for walnut tangential, R_a= 10,66 µm for walnut radial, R_a= 10,67 µm for beech radial, and R_a= 9.33 µm for beech tangential. The surface roughness values of tangential sliced veneers were found to be lower than the values of radial veneers. Also, differences were found in the surface roughness values of watered walnut and beech radial and tangential sliced veneers. They concluded that this difference may result from the growing location, annual ring structures, vaporizing conditions (temperature, duration), angle and openings of the veneer cutting machine, sharpness of the veneer cutting blade, cutting speed, the temperature and moisture content of the lumber during cutting, and the conditions for veneer drying.

In their study titled "Investigation of surface roughness of oak and beech wood parquets produced in Turkey", Unsal et al. (2002) intended to gain knowledge on surface roughness values of massive parquets produced from oak and beech in Turkey and to compare these with the surface roughness values of parquets produced in other countries. In measuring the surfaces roughness, they used a stylus tracing technique. The factory average was found to be R_a= 5,18 µm for oak tangential parquets and R_a= 5,07 µm for oak radial parquets, R_a= 4,73 µm for beech tangential parquets and R_a= 5,19 µm for beech radial parquets. The roughness values of beech parquets cut tangentially were found to be lower than the ones cut radially. While there is no significant difference between the two cutting directions for oak parquets, it was determined that the surface roughness of parquets cut tangentially was higher.

In their study, Ilter et al. (2002) intended to measure and evaluate the surface roughness of planed and sanded fir tree experiment samples after having been cut tangential and radially at humidity of the %12 and %30 in accordance with the feeding speeds applied in planning and sanding processes and to enhance the final use quality. The surface roughness was established via contacting a stylus tracing technique with regards to tree types, number of cutters, grit sizes, feeding speeds, and moisture content changes. They were treated in the planning machine with 2 cutters, 3 cutters and with feeding speeds of 5 m/min and 10 m/min. As a result, the smoothest surfaces were obtained on the planning machine at a moisture content of %12, with radial cut and 2 blades, and at a feeding speed of 5 m/min. It was concluded that smoother surfaces were obtained with the increasing grit sizes.

In their work, Goli et al (2003) made studies surface quality and surface formation mechanics some specimens of Douglas fir and oak have been routed at different grain angles with a 3-axis CNC machine, with up-and down-milling techniques.

Efe et al. (2003) used the tree types of acacia catechu and plain walnut in their studies and investigated the effects of cutting direction, number of cutters, and number of revolutions on the surface smoothness. The experiments were carried out at 4400, 6000, 7800, and 10,000 revolutions/min. With, 2 and 4 cutters in radial and tangential directions. At the end of the experiments, the best results were obtained for acacia in the tangential direction amongst the directions, at 10.000 revolutions/min amongst the number of revolutions and with four cutters amongst the cutters. The roughest surface was obtained for acacia and walnut woods at the radial direction with 2 cutters at 4400 revolutions/minute.

In their study titled "Studies on surface roughness of Scots pine and Chestnut timbers", Kilic et al. (2003) investigated the tree types, number of saw teeth, and feeding speeds on the surface roughness of cut massive wooden materials. According to the experiment results, the smoothest surface was obtained for Scotch pine wood with a 40-teeth saw the roughest surface for chestnut wood with 24-teeth saw. As a result, they stated that the Scotch pine and chestnut woods used commonly in furniture and woodworking industries might be cut with a 40-teeth saw at a feeding speed of 5 m/min to increase the surface quality.

In their study, Ors et al. (2003) investigated the effects of cutting direction and sanding on the surface smoothness for acacia and oak woods. According to the results of the study, smoother surfaces were obtained with acacia wood compared to oak, with wooden materials sanded tangentially compared to the radial direction, and with regards to number 80 sandpaper compared to number 60 and 40 sandpapers and the interactions of tree type-cutting direction, tree type-sandpaper type, and cutting direction-sandpaper type were found insignificant. The smoothest surface was obtained for the tangential cross-section of Acacia wood with 80 grit sandpaper.

In his study titled "Research on determination of surface roughness of Crimean pine wood", Aslandogan (2005) intended to determine the surface smoothness values of samples from the larch tree grown artificially after the planning and sanding processes. According to the results obtained from the study, the tangential cross-section of the larch tree grown artificially gave smoother surfaces compared to the radial cross-section, number 80 sandpaper compared to 60 grit sandpaper, and 3 cutters compared to 1 cutter. The wood from the larch tree gave average surface roughness values in the tangential cross-section compared to the radial cross-section. In the study, it was seen that the smoothest surfaces on larch tree samples were obtained in the 3-cutters planning carried out in the tangential direction.

A new type of sensor for three–dimensional evaluation of surface geometrical properties is presented by Sandak et al. (2005). The shadow scanner method was evaluated for rapid and accurate scanning of surfaces of various porous materials, particularly wood and wood based materials in both laboratory and industrial applications. It is suitable for industrial application. Surfaces were scanned without contact; thus, surface damage during measurement was avoided.

In his study titled "Surface roughness studies", Korkut (2005) gave short information regarding surface roughness and listed some researches carried out in Turkey and other countries on surface roughness to give some concise information.

In his study, Sogutlu (2005) investigated the effects of the cutting direction and sandpaper type on the surface roughness of wooden materials. He conducted his studies on woods of tree types such as acacia, pear, chestnut, durmast oak, and Taurus cedar. According to the results of his study, the highest surface roughness was obtained in oak, followed by chestnut, acacia, Taurus cedar, and pear. He stated that wooden materials with coarse textures gave rougher surfaces compared to the ones with fine textures.

In their study titled "The effect of planning on the surface roughness in wood material", Sonmez et al. (2005) investigated the surface roughness of some samples from tree materials treated in the planning machine. In this study, they used woods from acacia, pear, chestnut, durmast oak, and Taurus cedar. According to the results of the study, the highest surface roughness was obtained in oak and the lowest in pear; rougher surfaces were obtained in the radial direction compared to the tangential direction and in 2-cutters planning compared to the 4-cutters planning; the difference between in the tangential and radial directions for the Taurus cedar and the roughness values in the tangential direction was found to be less than in the radial direction, while oak displayed a different situation in that rougher surfaces were obtained in the radial direction. Also, they concluded that materials with coarse texture gave rougher surfaces than materials with fine texture, that roughness was more in the radial direction and was inversely proportional with the number of cutters used in planning, and that surface roughness decreased with the decreasing feeding speed.

In their study, Malkocoglu et al. (2006) determined the treatment properties of oriental beech, Anatolian chestnut, hairy alder, Scotch pine, and Oriental spruce woods grown in the Eastern Black Sea region. They carried out planning, milling, drilling, mortising, and sanding within this scope. In planning, the best surface quality was obtained at cutting angles of 15º-10º for hard trees and at cutting angles of 15º, 20º, and 25º for soft trees. Similarly, the best treatment performance was obtained for oriental beech at 25-20 knife marks on 25 mm and for other tree types at lower feeding speeds, that is at higher number of knife marks (20 knife marks). In this research, oriental beech amongst the hard trees displayed the best performance in all the treatment characteristics. When assessed in general, hard the types give higher quality treatment characteristics compared to soft tree types. Scotch pine amongst the soft tree types displayed a high-quality treatment characteristic despite its knotted structure. When the planning characteristics of wooden materials are observed, the best machining properties were obtained at low cutting angles (15º–20º). The woods from the soft tree types were not affected from wide cutting angles as much as the hard tree types were. The surface quality in the machining of the wooden materials increased with decreasing feeding speed or increasing the number of knife marks.

In their study titled "The effect of wood turning techniques on surface roughness of wood material", Aras et al (2007) carried out lathing via cutting and scraping technique on walnut, Oriental beech, linden, and poplar woods used commonly in lathing processes. They used empirical assessment criteria for surface assessment. They obtained the smoothest surface for lathed walnut via the cutting method and the roughest surface for lathed poplar via the scraping method. There were no significant changes in the surface smoothness values of poplar and linden. They suggested adopting the cutting method and walnut as the preferred material to obtain a smooth surface in lathing.

In his study, Malkocoglu (2007) made studies on the planning properties and surface roughness of woods from oriental beech, Anatolian chestnut, plain alder, Scotch pine, and Oriental spruce. In this study, he investigated the effect of cutting angle and feeding speed on the treatment quality. The lowest treatment characteristic was displayed by Oriental spruce. When the planning characteristics are considered, it was determined that oriental beech and Scotch pine displayed high values, Anatolian chestnut and alder medium values, and Oriental spruce low values. Especially, the treatment characteristics of wood displayed an increase with the decreasing cutting angle. According to the study, when the surface roughness at different cutting angles was analyzed, Oriental spruce and scotch pine displayed the best results with low roughness values. However, lower surface roughness values were observed for all the wood samples for the latewood than the earlywood. The surface roughness values were slightly higher for low cutting angles (15^o) than wide cutting angles (20^o and 30^o). Increasing the feeding speed reduced the surface quality in planning and decreasing the feed speed improved the surface quality. All the wood samples except for the Anatolian chestnut displayed lower roughness values.

In their study, Ratnasingam et al. (2007) determined planning properties of rubberwood grown in Southeast Asian region. This study shows that for machine planning of rubberwood, the recommended cutter marks pitch length of 1.2 mm, achieved with a knife rake angle of 20°, will ensure the highest resultant surface quality and processing yield.

In his study titled “Effects of wood machining properties of some native wood species on surface quality” Sofuoglu (2008) determined machining properties of European black pine, Cedar of Lebanon Sessile Oak and Black poplar widespread used and grown in Turkey. Perfect surface quality was obtained for hardwoods Black poplar and Sessile Oak at 25^o cutting angle of planning and for softwoods European black pine and Cedar of Lebanon at 15^o cutting angle of planning. Average surface roughness (Ra) values were obtained as 6,780 µm, 6,338 µm, 4,836 µm, 4,740 µm, in Sessile Oak, Black poplar, Cedar of Lebanon, European black pine, respectively.

In their study, Bustos et al. (2008) determined hardness, planning and moulding properties of tamarack wood from natural forests were evaluated on kiln-dried specimens following three types of drying schedules namely, high-temperature, elevated-temperature, and conventional drying. According to the results of the study, machining and hardness properties appeared not to be differently affected by the drying process. The best planning condition was obtained at 10° rake angle and twenty knife marks per 25.4 mm cutting length. This research showed that tamarack wood grown in natural forests has a good performance for planning and moulding processes. The best planning condition was obtained at 10° rake angle and 20 knife marks per 25.4 mm of feed speed.

Skaljic et al. (2009) determined surface roughness values of planed beech, oak and fir specimens.

Farrokhpayam (2010) studied the characterization of surface defects in dark red meranti, melunak, and rubber wood in the planning process.

In their review study, Naylor and Hackney (2013); wood machining research is evaluated to determine the general cutting mechanics.

In his study, Owusu et al. (2015) determined planning and sanding properties of Volumes of timber logs (dead trees) in the Volta Lake in Ghana. Surface quality performance increased with decreasing rake angle and feed speed. The magnitude of the chipped/torn grain defects decreased with decreasing rake angle and feed speed.

In his study titled “Some machining properties of 4 wood species grown in Turkey”, Sofuoglu (2014) determined machining properties of European black pine and Cedar of Lebanon as two softwood species and Sessile Oak, Black poplar. Generally, machining properties are the performance of the wood material versus of such as planning, shaping, turning, mortising, boring and sanding operations. Perfect surface quality was obtained for hardwoods Black poplar and Sessile Oak at 25^o cutting angle of planning and for softwoods European black pine and Cedar of Lebanon at 15^o cutting angle of planning.

An artificial neural network (ANN) approach was employed to predict and control surface roughness in a computer numerical control (CNC) machine. Five machining parameters (cutter type, tool clearance strategy, spindle speed, feed rate, and depth of cut) were used. The present research results can be applied in the wood machining industry to reduce energy, time, and cost (Sofuoglu, 2015a).

In this paper, CNC machining parameters were optimised using the Taguchi design method on the surface quality of massive wooden edge-glued panels made of European larch. Three machining parameters (tool clearance strategy, spindle speed, and feed rate) and their effects on surface roughness were evaluated. The surface roughness, both, increased with increasing feed rate. Optimal cutting performance was obtained for a tool clearance strategy of an offset 16000 rpm spindle speed and 1000 mm/min feed rate cutting settings (Sofuoglu, 2015b).

In their study, Belleville et al. (2016) determined machining properties of Australian plantation-grown eucalypts. Within this scope, they carried out turning, planning, sanding, boring, mortising and shaping. This research confirmed that high-density plantation-grown Australian hardwoods can perform well during moulding, drilling, sanding, and routing processes. However, turning trials showed to be difficult for *Eucalyptus cladocalyx*, *Eucalyptus camaldulensis* and *Corymbia maculata* from one location.

In this paper, the optimization of CNC machining parameters was conducted using the Taguchi design method on the surface quality of massive wooden edge-glued panels made of Scots pine. Five machining parameters (cutters type, tool clearance strategy, spindle speed, feed rate and depth of cut) and their effects on surface roughness were evaluated. Optimal cutting performance for Ra and Rz was obtained for Cutter 1, at a tool clearance strategy of a raster 16,000 rpm spindle speed, 1000 mm/min feed rate and 4 mm depth (Sofuoglu, 2017).

In their study titled "Planning and Turning Characteristics of *Gmelina arborea* Grown in Two Ecological Zones in Ghana", Mitchual et al. (2018) determined machining properties of *Gmelina arborea*. Ghana where *Gmelina arborea* is cultivated, a feed speed of 6 m/min at a 30° cutting angle produces the best planning performance.

This paper determines the machining properties and possible utilization of punak, meranti bunga, mempisang, suntai and pasak lingo originated from Riau Province. Research revealed that planning, shaping, boring, turning and sanding properties. Punak and pasak linggo had good and very good machining properties (Supriadi and Abdurracan, 2018).

The objective of this review paper is to review how it is affected by different machining factors. The current challenges associated with various machining factors, process monitoring, and sensor selection were identified and explained (Nasir and Cool, 2020).

The study aims to obtain optimum machining conditions by investigating the effect of machining parameters of bamboo material on surface quality. The evaluation was performed for four- machining parameters (cutters type, spindle speed, feed rate and depth of cut) and their effects on surface roughness. Roughness values increased with increasing machining depth and cutter feed speed. Roughness value decreased by increasing the number of blades in the cutter (Aykac and Sofuoglu 2021).

The effects of different machining parameters (cutting direction, end mill type, spindle speed, feed rate, cutting depth, tool diameter) on surface roughness values of thermally Scotch pine, eastern beech and linden cut in a CNC router machine were examined. Roughness generally decreased in the thermally treated wood materials. Spindle speed increased, the roughness values of all wood specimens decreased. The feed rate increased, the roughness values increased. The end mill type, feed rate, and spindle speed were the most influential parameters on the surface roughness (Budakci et al., 2021).

3. Conclusion

The following results are obtained when the studies are assessed in general.

For a good treatment in all the processes related to the treatment of the wooden materials, the cutters have to be sharpened, the machines have to be maintained and stable.

Placing blades at a large number to the blade head, it should be provided that all the cutters contributed to the cutting process within the same cutting circle.

Cuts that are not deep should be applied. The cuts should be superficial, and sometimes it is useful to make the first rough cuts, then the superficial last cut.

Surface quality is improved with the increasing number of cutter marks per unit distance. The number of blade marks per unit distance should be kept high. To increase the number of blade marks per unit distance, either the cutting speed should be increased or the feeding speed should be decreased.

The most appropriate feeding speed and the combination of blade numbers, which may differ for each tree type, should be provided.

Generally, treatment defects are observed in the parts without smooth fibres in the treatment of wooden material. The materials to be used should be with smooth fibres and be cleared from knot formations that might cause fibre deflection. It shall be appropriate not to use massive wooden materials with knots on areas on which a good surface quality is required during production.

Examining the studies, the most suitable cutters should be chosen for each wood type and they should be sharpened.

The most suitable treatment condition for each wood type used in the industry should be made into tables.

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