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VISUAL GRADING OF SMALL-DIAMETER POPLARS FOR PEELING USE

Small-diameter poplars (Populus euramericana, or Populus deltoids, or Populus nigra) are an important raw material resource for the wood and paper industry. Both manufacturers and governments are increasingly interested in obtaining this raw material from poplar plantations. A small-diameter poplar is between fifteen and thirty five centimetres in diameter at breast height. In this study, small-diameter poplars were graded visually for use in peeling. Traditional rules currently in use were applied when grading small-diameter poplars, and standard layer-sorting rules were used on the outputs from the peeling process. The field study has shown that standard sorting by layer doesn't correspond well when small-diameter poplars are sorted. For instance, the best small-diameter poplar is rarely classified as class A or B by standard layer sorting. In this research, small-diameter poplars are classified accurately using specific, alternative rules, and the grading scale ranges are presented. Some defects, such as knot and splits, have a strong influence on the quality of the final product, but often, existing standard-sorting methods do not reflect the degree to which the defects have affected the final product. A new method for classifying small-diameter poplars is presented, which groups the wood by its value in the final product.

Keywords: visual grading; small-diameter poplar; defect; output

Introduction

Visual grading is essential for selecting the type of application

Wood scaling regulations are used to classify raw materials by grouping them by their quality. The quality of a product, which includes both visible and invisible characteristics, determines the use to which the wood can be applied. Each sorted group is appropriate for a particular application. Visible characteristics are important in classifying logs and timbers because their application is affected by defects. Unfortunately, invisible characteristics (mechanical and chemical properties) also have a key role in material use, and visible defects are affected

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by invisible characteristics. Knots and the slope of the grain, for example, influence the mechanical properties of wood and decrease its bending strength. The output and efficiency of sawmills and plywood mills are improved when the wood contains fewer visible defects. Even though visible characteristics are assessed during the machine stress rating of lumber, visual grading is also essential for selecting the type of application for the lumber. Forest product suppliers, attend to the visible characteristics of the lumber, and their requirements are determined by process technology. Product processes are designed based on the wood material available. Some of those processes match factories that are designed to use small-diameter poplar (SDP; *Populus nigra*. or *Populus alba*.). Some of the poplar bulks, however, have visible defects, and therefore, those bulks are not accepted by product processes for those factories using SDP. Frost-check defects, for instance, inhibit the application of SDPs in those factories. In this study, the scaling regulations for sorting log groups were investigated, and standard regulations were used to classify SDP. Research was performed to grade and sort the forest products for the wood-based panel and cellulose industries. In addition, structural products made with small-diameter log material also included oriented strand boards and parallel strand lumber; all of which are now commonplace in the timber marketplace. Poplar plantation trees are an important resource for a variety of lumber production processes. Trees from those plantations are considered small diameter if they are less than thirty centimetres in diameter at breast height [Paun and Jackson 2000; Howard 2001; Willits and Roos 2004].

Visual Inspections and Classifying SDP

Visual inspection is a simple, convenient, and non-destructive evaluation method. Southern pine (*Pinus taeda L.*) lumber has a higher visual grading yield than Japanese cedar (*Cryptomeria japonica* (L. f.) D. Don), Taiwania (*Taiwania cryptomerioides Hayata*), and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) do. Most of the defects in these four softwood lumbers are knots, whereas the other defects, such as stains, decay, wanes, crooks, warps, pitting, and twists, are few. Knot types include both loose knots (about 25%) and tight knots (about 75%). Hence, knots are the most important factor in judging lumber grades by visual inspection (the Chinese National Standard) because lumber cut from small-diameter Japanese cedar and Taiwania plantation trees include many knots (in number and in size) in Taiwan. The mechanical properties of wood are significantly influenced by the number and size of its defects.

Southern pine lumber has a higher machine stress rating (MSR) than Japanese cedar, Taiwania, and Douglas-fir. Higher visual grades mean higher dynamic modulus of elasticity (DMOE) and modulus of elasticity (MOE) values for the lumber. Most of the criteria used in the visual grading of the lumber do not correlate closely with specific properties, and visual grading is not as precise as machine grading [Wang et al. 2008].

The logs used in the study [Fernandez-Golfin et al. 2007] have a standard strength group rating of C14, and visual grading was performed on a combination of strength groups including, C14, C16, C18, and C20. Strength grade standards DIN 4074-1, VPS-SRT-2, and PR EN 14544 were calculated for the logs and were compared with the standard BS EN 14081-2. Most of the logs fit a standard and visual grading of VPS-SRT-2. The efficiency and mechanical properties of small-diameter timber (SDT) were classified as first grade, second grade, and out-grade [Fernandez-Golfin et al. 2007].

Incorrect classification by visual grading standards

The PR EN 14544 visual grading standard exaggerated the number of rejects, greatly underestimating the real strength of the material. The DIN 4074-1 grading standard identified the first-quality timber acceptably and correctly graded reject timber. It performed poorly, however, with the second-quality grade, strongly underestimating its quality and incorrectly classifying many second-class pieces as rejects. The VPS-SRT-2 standard correctly identified the first quality material and adequately graded reject material. Second quality material, however, was undervalued or overvalued, almost to the same extent. The VPS-SRT-2 standard not only identified a greater percentage of timber as first quality than the DIN 4074-1 standard, it also identified a smaller percentage of reject timber. The most evident errors with both standards, therefore, involve the identification of second-quality material, although these errors are of less importance with DIN 4074-1 standards because it undervalues, rather than over values, the material.

Visual grading is tedious because of the number of variables to be measured, and it is not very efficient, given the high number of rejects obtained. The most suitable course of action might be to focus on designing mixed-grading systems (as used for sawn timber), integrating measurements made using non-destructive systems (ultrasounds, penetrometers, etc.) and rapid visual evaluations of different features (knottiness, curvature, and the presence of juvenile wood, etc.) [Fernandez-Golfin et al. 2007].

There is a need to design a mixed-grading method based on the use of non-destructive tests and the visual evaluation of specific wood features. Erikson et al. [2000] studied the mechanical properties of lodgepole pine (*Pinus contorta* Douglas ex Loudon), grand fir (*Abies grandis* (Douglas ex D. Don) Lindl.), and Ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson) and their corresponding economic value as dimensional lumber produced from typical overstocked forest stands in northern Idaho. The lumber was visually graded and tested for MOE and modulus of rupture, and each piece was sorted into two categories: visual structural light framing and MSR. This study indicated that two of the three species tested had good visual and mechanical characteristics.

Limitations of log-grading standards for final lumber quality

Results show that the strength of small-diameter round timber is high, corresponding to the highest-quality sawn timber. Small-diameter timber can be used in load-bearing structures, and it is, in fact, a strong material. Simple, visual rules are adequate for strength grading. The results provide a basis for the start of an international standard for the structural use of small-diameter, round timber [Ranta-Maunus 1999].

Small-diameter timber is often of lower quality and lesser value than larger saw timber. Small-diameter hardwood timber, therefore, has traditionally been used for pulpwood, but it can also be used for lumber and residue production [Perkins et al. 2008].

Research [Craft and Emmanuel 1981; Craft 1982] has indicated that short-length logs with fewer sweeps have a greater yield than longer-length logs with more sweeps. Clearly, to maximize the profitability of sawing small logs, one must maximize the product yield from SDT.

Grading rules exist for logs with less than an eight inch diameter at the small end. For logs with a diameter at the small end of more than eight inches, the log-grade rules of the U.S. Department of Agriculture, Forest Service (USFS), are used [Rast et al. 1973]. Mills have to develop their own grading criteria for six inch and seven inch logs. Logs with large portions of unsound wood or obvious sweeps have a lower yield.

When dealing with large, crooked, or irregular logs-especially hardwood – a simpler machine might be a better choice, although both productivity and lumber recovery will be less [Michael et al. 2009].

In fact, the recovery rate obtained with the Economizer Small Log Mill is quite high for a small, mobile plant and exceeds that obtained from stationary, Chip-N-Saw mills under similar small-log conditions [Fahey and Hunt 1972].

Grading for sawmills is usually carried out in log-grading facilities. The main criteria for grading logs are the dimensions of the log (normally, the length of the log and the diameter of the smaller end are measured); also graded are the quality parameters of the log (wood species, knots, curvature of the log, etc.). Petutschnigg and Katz [2005] developed a model to analyse the effects of the quality characteristics of logs on the quality of the lumber. Based on 112 logs, it was not possible to make definitive statements about the connection between log quality and lumber quality in general. This is because it is not the characteristics of individual logs that are important, but rather, the combinations of different log-quality characteristics which affects the quality of the lumber produced. In that study, the main log-quality factor influencing lumber quality was the combined occurrence of curvature and discolouration. By grading the logs according to the log-grading rules deduced from their study, a more-efficient cutting yield was achieved. Sawmills can use the results of that study to define new criteria for log grading as well as to make differentiated log purchases.

Hecker et al. [2000] investigated the connection between log grading according to various national and European log-grading standards and the quality of the lumber produced. They found no adequate forecast method, however, for predicting lumber quality on the basis of the log grade.

In Italy, poplar plantations represent an important source for wood products, particularly high-quality veneer logs. Italian plantations offer favourable conditions for the introduction of forest mechanization, especially for ease of access and industrial management. Mechanized log-making in Italian poplar plantations has not caused any significant reduction in the value of the veneer recovered, compared with traditional motor-manual log-making. Length--measurement errors are smaller with mechanized processing, whereas the frequency and severity of log surface damage for both treatments was the same [Spinelli et al. 2011].

Increasingly, SDTs are used as posts along highways. That trend will continue to increase in the future because of the high cost for large-diameter timber stands. Most motorway round-beam diameter is between 10 to 12.5 cm for smaller posts and 15 to 17.5 cm for larger posts [Paun and Jackson 2000]. The application SDTs by sawmills were analysed by Becker [1998], and the volume of product boards from SDTs was less than the volume of boards from large-diameter timber in an eight hour period.

Visual grading can be made according to certain criteria in the standard NF52001. The specific criteria in that standard include the width of annual rings, knot dimensions, checks, resin pocket, bark pocket, grain angle, and stain and sap stain defects. The standard includes three-class grades: ST1, ST2, ST3, which is in accordance with the defects allowed in C18, C24, and C30 in the EN 388 standard [CEN 2003]. Grain slope, wane, and knots are the most critical defects observed in visual grading [Bodig and Jayne 1989].

The MOE of structural-lumber–grade logs was reviewed by Edund et al. [2006]. They found a good relationship between the MOE of logs and the construction grade of lumber, and low MOE logs produced construction lumber of a low quality.

Uses for SDPs

SDTs have a variety of uses. Experimental observations are necessary to make optimal use of their products, so that these materials can be appropriately classified and selected for each use. Nowadays, SDPs are classified based on the specific requirements of each factory. Groups of SDPs have to be used for certain applications because their output is different. If these groups and their outputs were identified, SDPs could be more optimally used by the wood industry. Visual grading rules for SDTs aren’t available for peeling use. The visual grading process of poplar bulks is based on the use of those bulks at local plants. Visual grading rules for SDPs should be prepared. The number of ply grades (grading groups) should correspond to the number of bulk grades in the proposed rules because production efficiency of the ply is increased with proper grading groups for SDP. Ply groups of A and B, for example, should result in the first grades of poplar bulks. Another objective of this study was to determine those defects that have an important effect on the grading of poplar bulks. The frequency of the defect and its size were measured, and the production efficiency related to various groups of SDP will be determined. The goals presented in this article include sorting of SDPs for peeling and calculating the outputs as a percentage of each group.

Materials and methods

This research was carried out at the Amol peeling mill (Iran). Visual grading was performed according to scientific references [ISIRI-1275, APA-PS1-95], along with the criteria of plant suppliers. The standard number 1275 from Iran and the Product Standards of the American Plywood Association were used to grade logs and to sort ply. First, the SDP was graded, and then, each log had its wood layers extracted and sorted, and finally, production efficiency was calculated for the different ply classes. The average dimension and frequency of the defects was measured for SDP, and the average defects were calculated for different groups of logs. This allowed a proposed range of defects to be determined for each of the different grades. The limits of the defects allowed were specified according to the average measured defects of the SDP, the rules of the national standard [Standard number 1275 in Iran and the Product Standard of American Plywood Association], and a field survey (criteria of plant suppliers). Because the visually graded groups of SDPs were determined by the methods outlined, the grading criteria were usable for SDP. The stages of this method are shown in figure 1. In addition, the shopping criteria from peeling mill suppliers and the grouping criteria in scientific sources were identified for SDTs. Because the SDP sorting was theoretical, the visual scales of poplar bulks survived for peeling use. The defect types for poplar bulks were then measured, and the production efficiency of the ply was calculated for the sorted groups. At that point, the defects that had an important influence on the sorting were identified. By determining a dimension range for the defects, the poplar bulk grading becomes simple and practical in a field survey. Sorting performance can be measured based on the new rules, with clear layers from poplar bulks having the highest quality.

Log volumes were calculated using the Smalian formula, as follows:

$$V = \frac{f\left(ds^2 + dl^2\right) L}{2} \tag{1}$$

where *V* is the log volume (in cubic meters), *f* is the metric ratio (0.7854), *ds* is the diameter of the small end, *dl* is the diameter of the large end, and *L* is the log length.

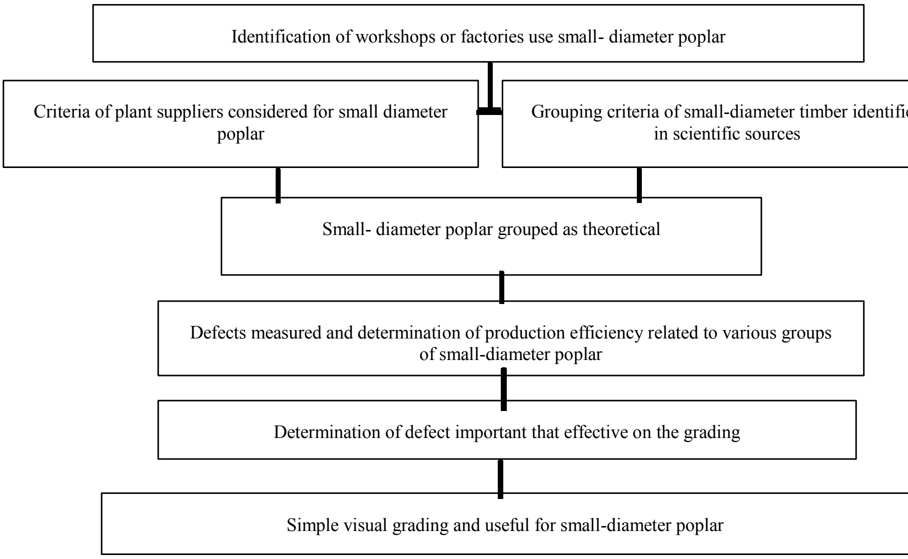

Fig. 1. Experimental methods for determining the criteria of visual grading of small-diameter poplar

The ply volume was calculated with the following formula:

$$V = L \times b \times t \tag{2}$$

where *V* is ply volume (in cubic meters), *L* is the ply length, *b* is the ply width, and *t* is the ply thickness.

Outputs from the SDP were converted to layers with the following formula:

$$\text{Ply extraction efficiency} = \frac{\text{Ply volume total}}{\text{log volume total}} \times 100 \tag{3}$$

Results and discussion

The total volume and the number of SDPs were determined for each grading group, and then, the total volume of the ply production and the efficiency percentage were calculated. Sorting performance related to previous rules, showed that grading groups of production layers did not correspond to the visual quality of poplar bulks. The production layer efficiency of the poplar bulks equalled 64.14, 61.32, and 64.83 percent from the first to the third grade, respectively. First-grade poplar bulks produced the greatest number of C-grade ply, and the production efficiency of the ply related to first-grade poplar bulks were as follows: A = 17.34, B = 12, C = 30, and D = 4.8 percent. Second-grade poplar bulks produced the greatest number of A-grade ply, and production efficiency of the ply related to second-grade poplar bulks were as follows: A = 26.02, B = 14.86, C = 8.92, and D = 11.52 percent. Third-grade poplar bulks produced the greatest number of C-grade ply, and production efficiency of ply related to third-grade poplar bulks were as follows: A = 18.72, B = 17.80, C = 28.31, and D = 0 percent. Production efficiency of poplar bulks, therefore, isn't proper, based on the current grading rules, and the rule should be revised based on new rules with clear layers produced by quality bulks.

The number and the dimensions of defects were measured as sorted bolts. The defects in SDP included knots (unsound or sound, loose or tight, dead), cavities or holes, stains or discolouration specks, surface decay, splits or checks (star, compound, heart check or ring shake, frost cracks), abnormal section conditions or ovateness, irregularly shaped logs, tapers in long logs, and sweepers. Splits or checks, in particular frost cracks, were the most frequent defects in poplar bulks, followed by stains or discolouration specks. Peeling mills do not purchase poplar bulks with frost cracks, sweepers, or that are irregularly shaped.

The number and dimensions of defects were also measured at the production layers. Defects in the production layers were the same as those in the poplar bulks. Stained streaks, extraction, and surface damage (loose side, rupture, swirls, raised grains, and gaps) were the most frequently seen defects in the production layers.

The proposed grading rules for SDP are presented in table 1. The range of defect measurements and the number of defects allowed or unacceptable in each group were determined according to the mean average of the defect measurements, the national standard rules for grading (Iran national grading 1275 for logs and the Product Standards from the American Plywood Association), and by the criteria of the peeling mills.

The clear cutting length is completely free of defects. The number of permitted clear cuttings is small for grade one and the percentage of the log length required for clear cuttings is large for grade one. On the other hand, the number of clear cutting is unlimited for grade three, and the log length required in grade three clear cuttings is smaller than that in grade one.

The dimensions of the product layers were equal to 244 by 122 by 0.22 ±0.01 cm (length by width by thickness). The PS1 rules can be simplified to four categories as follows: (1) knots; (2) splits or open defects and gaps; (3) surface situations, such as loose side, raised grain, grain rupture, rough cuts, uneven surface, swirls, and the slope of the grain; and (4) patches and defect total.

In conclusion, the production efficiency percentage based on the new sorting rules and proposed ranges offer the best performance in field surveys, for example, ply groups A and B were produced by the first grade of poplar bulks (tab. 2).

Table 1: Proposal grading range of small-diameter poplar

<table>
<tr><th colspan="2" rowspan="2">Defect</th><th colspan="3">Grade</th></tr>
<tr><th>First</th><th>Second</th><th>Third</th></tr>
<tr><td colspan="2">Length to centimetre</td><td>160</td><td>150</td><td>145</td></tr>
<tr><td colspan="2">Knot diameter (unsound, dead, sound and tight) at each meter length several knot or one knot)</td><td>3 centimetre for sound knot, unacceptable for dead knot</td><td>5 centimetre</td><td>8 centimetre</td></tr>
<tr><td colspan="2">Surface decay</td><td>None</td><td>Length ×width at each meter bolts length 8 × 13 centimetre and depth were not more than 1 centimetre</td><td>Length × width at each meter bolts length 25 × 30 centimetre and depth were not more than 2 centimetre</td></tr>
<tr><td colspan="2">Checks, ring shake and splits</td><td>None, except of slight checks or slight shakes</td><td>Maximum length 10 centimetre, without star checks and spiral cracks. If bolts have not checks and split, ring shake is until 5 centimetre allowed. Checks run from surface into heart are unacceptable, but checks near the heart are allowed</td><td>Maximum length (all of the defects) 15 centimetre</td></tr>
<tr><td colspan="2">Frost cracks</td><td>None</td><td>None</td><td>None</td></tr>
<tr><td colspan="2">Abnormal conditions of sections (distance from the largest to smallest average diameter at one end, to centimetre)</td><td>Bolts diameter is larger than 26 centimetre, only, 1 centimetre allowed and 0.5 centimetre allowed for smaller bolts diameters</td><td>1 centimetre</td><td>1 centimetre</td></tr>
<tr><td colspan="2">Taper of the long log (the difference between the two end diameters), reduce diameter for each meter to centimetre</td><td>1 centimetre</td><td>1 centimetre</td><td>1 centimetre</td></tr>
<tr><td colspan="2">Sweeper (the distance between the tape and the geometric centre, for each meter to centimetre)</td><td>1 centimetre</td><td>1 centimetre</td><td>1 centimetre</td></tr>
<tr><td colspan="2">Off centre hearts (offset or removed pith) (distance from pith to geometrical centre to centimetre)</td><td>1.5 centimetre</td><td>2 centimetre</td><td>2.5 centimetre</td></tr>
<tr><td rowspan="2">All of defects (above mention, and unmentioned)</td><td>The maximum number of clear cutting permitted</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>The minimum length of clear cutting permitted (minimum proportion of bolts length required in clear cuttings)</td><td>The proportion of 5 to 6 or (5/6) (for bolt 1.60 metric is equal 1.33 meter)</td><td>The proportion 2 to 3 or (2/3) (for bolt 1.60 metric is equal 1/07 meter)</td><td>The proportion 1 to 2 or (1/2) (for bolt 1.60 metric is equal 80 centimetre)</td></tr>
</table>

Table 2. Total volume of small-diameter poplar and production efficiency percent on the basis of new sorting (tabs. 4 and 5) and also, ply total volume of each grading groups related to each logs groups

Number of bolts grade (table 4)	Bolts total number	Bolt total volume (cubic meter)	Number of ply grade (table 5)	Ply total number (1.30 × 7.25 meter length × width, and thickness approximate 2 until 2.2 millimetre)	Ply total volume (cubic meter)	Waste plys (cubic meter)	Production efficiency of ply (%)
First	9	1.124	A	17.5	0.364	0.051	32.38
			B	13.5	0.285	0.062	25.35
			C	0	0	0	0
			D	0	0	0	0
	Total			31	0.649	0.113	57.73
Second	6	0.691	A	7	0.147	0.013	21.27
			B	8.5	0.185	0.038	26.77
			C	4.5	0.092	0.015	13.31
			D	0	0	0	0
	Total			20	0.424	0.066	61.35
Third	5	0.564	A	0	0	0	0
			B	5	0.114	0.010	20.21
			C	9	0.186	0.016	32.97
			D	0	0	0	0
	Total			14	0.3	0.026	55.18

Applications for poplar wood spans a wide range of uses. The special demands of consumers or plant suppliers are sorted based on the characteristics of SDP. Groups of SDP selected by consumers by the quality or production outputs are increased by this method. Production efficiency decreases with some SDP defects. SDP sorting is important for peeling mills because they need logs from the highest-grade group. Effective defects for peeling are empirically understood by processing operators. SDP that has frost splits are not purchased by plant suppliers. These effects and SDP grading groups were determined in this study. Grading rules, such as USFS, APA-PS 1, and 1275 in Iran, aren't related to SDP. Bolt numbers of the first and third groups produce more of grade two when based on the Standard 1275 grading rules. SDPs have more layer production in group C than in group A when based on APA-PS 1. Dead knot and frost cracks (or splits) have a great influence on the SDP grading and their layer outputs. These defects were taken into account by dealing with the rules of plant suppliers. Unsound or dead knots and splits were defects that were prevented for first-grade logs, and frost cracks were also unacceptable in all sorting groups. The limiting defects have been presented in table 1. The number, location, and diameter of knots from SDP are very important during peeling, whereas discolouration streaks are more often seen with SDPs, and this defect has a small role in SDP grading.

When SDP has a diameter larger than thirty centimetres, and it has been first graded, the peeling output is more efficient than with other SDPs (tab. 1). Peeling machines cannot use thickset SDP (diameters over thirty centimetres) converted to layers because these machines are designed for light-weight use. Heavyset SDPs cannot be rotated by the peeling machine. Heavy trunks and defects, such as frost cracks, sweepers, and abnormal conditions of any bolts, stop the continuous peeling process. When SDP is sorted by an accounting criteria [Bayatkashkoli et al. 2008], the output and speed of layer production was increased by thickset (from twenty five to thirty centimetres) SDP. The diameter of SDP is usually more than thirty centimetres. Peeling machines, therefore, have to use a special technology for SDP. When SDPs are smaller or larger than the specified diameter range, the trunks have not been used for peeling because of the output efficiency and machine technology. Fast-growing wood species or plantation trees, such as poplars, have different defects than those of forest species.

Visual grading of defects with the new rules:

Insect cavities are observed after the initial stage of decay because decaying wood is a favourite food of insects such as beetles, and rotted wood hosts insect worms. Insect cavities are like the decay that is addressed in Table 1 and are measured as part of all of the defects or surface decay. Additionally, trunks of poplar can suffer decay because of their wood texture and density.

The ring shake defect is seen in third-grade bolts, and reduces peeling output. The depth of the ring shake is slight in first-grade bolts (tab. 1). A layer rupture in peeling is caused by splits and ring shakes. Splits, gaps, and checks in SDP are unacceptable for A grade ply. Frost cracks on the trunk surface are important in SDP sorting. Changes in temperature, the low thermal conductivity of wood, texture loss, and thin bark of bolts are causes of frost cracks. SDP is capable of developing this type of defect. Frost cracks have a strong influence on the use of poplar. Some of the wood industry, such as peeling mills and match-production factories, do not use poplar with this type of defect. This defect, therefore, isn’t allowed in any of the sorting groups in the new proposed rules (tab. 1).

Sound knots in SDP are rated more highly than dead knots are because plantation trees are pruned, and tissue repair in poplar plantations is more rapid than it is in natural forest trees because poplar is fast growing. The spiral grain of a knot is caused by layers that have separated because the knot shrinks at a different rate than the surrounding texture. The SDP knot texture applies weak pressure against the peeling knife. Spiral grain of the branch texture creates strength against gravity, but the defect is the most important for SDP and production layers. Quality classifications of SDP and its production layers are reduced by this defect or by patches in the new rules (tab. 1).

Discolouration specks and stain streaks have been seen with SDP. This defect is natural and inborn. Peeling outputs are not decreased by this defect, but it does influence finishing, painting, and gluing. Discolouration specks and stain streaks have a different acidity (PH) than sound-textured wood. Pitch pockets and discolouration defects have caused weak finishes and poor adhesion. This allowable limit of the defect is slight in the grade A classification.

Extraction or damage to the surface, loose side, patches, open defects, and gaps should be limited in all layer classifications, but these defects have only been slightly limited with previous sorting standards. Slope of the grain can strongly influence plywood quality. Production layers easily separate in the grain direction, but are resistant to vertical force. Usually, layers are joined together by sew and punch. Grain direction of adjacent layers should be parallel. In figure 2, the punches and sewing thread are perpendicular to the grain direction, and junction has been sewn up with a tight coupling. Otherwise, the connection will be torn. Production layers with a slope in the grain will rupture during the drying and transport process. The defect can be limited during group sorting.

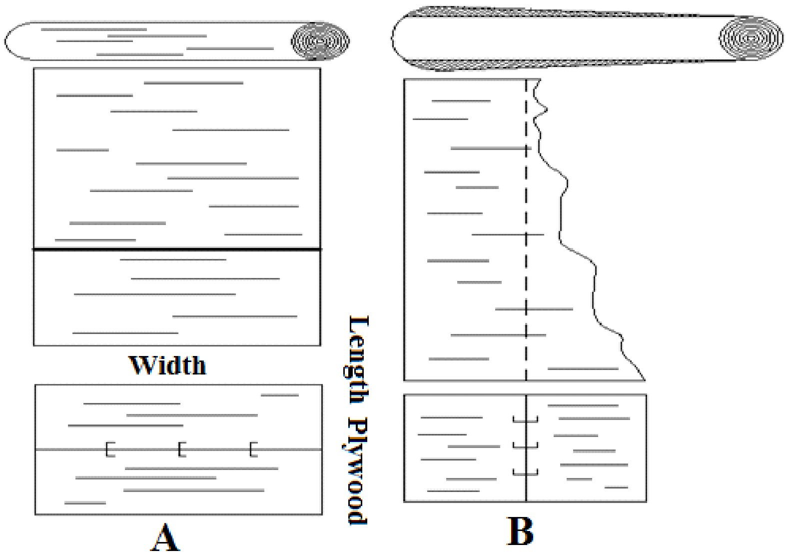

Fig. 2. The parallelism of grain direction at adjacent layers (tight junction) (A), and easily separation of connection at the perpendicular of grain direction (B)

Low width layers result from the taper of long logs. This defect is the same as the slope of the grain because of the above processing problems (fig. 2). If the difference between the diameters of the two ends of the trunk is large, primary rotation of the peeling will be a product of the layers with the lowest width, and additional layers will have to be sewn into the final product layer.

Irregularly shaped logs are an abnormal condition of the various log sections, and the distance from the largest to the smallest average diameter is more than a log with a circular section. The distance between the tape and the geometric centre is also larger in sweeper logs. Outputs are decreased by SDPs with large diameters and those that are irregularly shaped or sweepers caused by bolt shaking and the centrifugal force of peeling. These defects stop the continuous peeling, and production efficiency, process speed, and production quality are decreased (fig. 3).

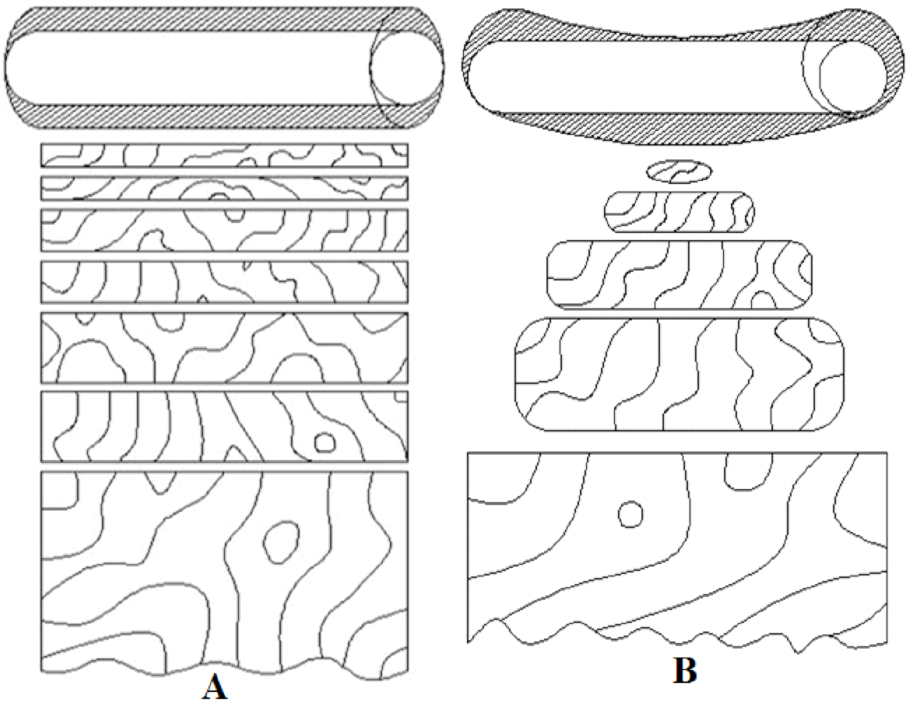

Fig. 3. Production layers of bolts with oval section (A) and sweeper (B)

Large-diameter bolts, irregularly shaped sections, and sweepers that impact the peeling machine blade can cause trunks to be dropped from the peeling machine. Sweeper bolts are associated with reaction wood (tension wood) and off-centre hearts. Additionally, layer surfaces that result from defective bolts have surface damage, loose sides, grain ruptures, rough cuts, and uneven swirls and slopes in the grain. These defects influence finishing and painting. Logs with large portions of unsound wood or obvious sweeps have a lower yield [Rast et al. 1973; Michael et al. 2009]. This is an important defect in the difference between graded logs. The main criteria for grading logs are the dimensions of the log and the quality parameters of the log (the knots, the curvature of the log, discolouration; [Petutschnigg and Katz 2005]). Grain slope, wane, and knots are the most critical defects during visual grading [Bodig and Jayne 1989].

Smooth and glossy surfaces are necessary for plywood, but product cost, raw materials for finishing, and finishing time are increased by defects. The primary stage of polishing is caused by raised grains, and the finishing stages should be increased until the surface is perfected. These defects, therefore, are limited during sorting classifications (tab. 1), and the proposed range of sorting groups is related to the defects effects on the final products.

Ply production and the efficiency percentage of peeling were calculated based on the data in table 1. These results provide a new sorting scheme, as shown in table 1.

Output and sorting results from previous rules classify more first-grade products as grade C, but the proposal in table 2 classifies more products as grade A. In addition, B and C layers classify trunk products as second and third grade, respectively (tab. 2). This proposed sorting standard, therefore, is more precise than previous grading rules (tab. 2). The requirements specified in the standards ISIRI-1275 and APA-PS1-95 are available as published data. Factory operators complete the sorting of log defects with excessive detail. These scaling regulations cannot be used to classify small diameter poplars. The classifying rules should determine the use to which the logs can be applied. This proposed sorting standard is based on the application type, and after this, the peeling output is more efficient than with previous sorting standards.

Plantation trees have many knots (number and size; [Wang et al. 2008]), but poplar trees also have many splits, surface decay, and discolouration. Visual grading is required to select trees for their use in non-destructive systems. The most suitable course of action might be to focus on designing mixed-grading systems [Fernandez-Golfin et al. 2007]. Species with good visual grading have proper mechanical characteristics [Erikson et al. 2000; Wang et al. 2008]. The strength of small-diameter, round timber corresponds highly with the highest-quality sawn timber [Ranta-Maunus 1999]. In conclusion, sorted layers correspond to new scales of grading, and superior layers result from the highest grade of poplar bulks (tab. 2).

Conclusions

Applications for SDP change, depending on the defects of the various sorted groups. Visible defects are affected by invisible characteristics. Standard regulations are used to classify SDP and its plywood, and poplar trunks are sorted for peeling and output percentage is calculated for each group. Grading rules, such as USFS, APA-PS 1 and 1275 in Iran, aren’t proper for experimental applications. Splits or checks, in particular frost cracks, occur with greater frequency than other defects do in poplar bulks, followed by stain or discolouration specks. Stained streaks and extraction or damage to the surface (loose side, rupture, swirls, raised grain, and gap) is more frequent than other types of defects in production layers. In the proposed grading rules, SDP with frost splits, sweepers, and irregularly shaped bolts will not be purchased by plant suppliers. Frost cracks are not allowed in any of the sorting groups. Dead knots and frost cracks (or splits) have great influence on SDP grading and their layer outputs. Sound knots in SDP are more frequent than dead knots. Quality classification of SDP and production layers have been reduced by this defect or by patches. Ring shake defects reduce peeling output, and the depth of a ring shake should be slight in first-grade bolts. Defects such as splits, gaps, and checks in SDP are unacceptable for grade A layers. Heavy trunks and defects such as frost cracks, sweepers, and abnormal conditions of the bolts stop continuous peeling and reduce production efficiency, process speed, and production quality. Trunks of poplar can decay because of wood texture and density. Discolouration specks and stain streaks have been seen in SDP. Pitch pocket and discolouration defects have caused weak finishing and poor adhesion. These defects should be slight in grade A layers. Extraction or damage of the surface, loose side, patches, open defects, and gaps are limited in all layer classifications, but these defects have only been slightly limited under previous sorting rules. The grain slope strongly influences plywood quality. Production layers with grain slope defects will rupture during the drying and transport process. Grain slope defects should be limited to specific sorting groups. These defects (slope of grain and loose side) influence finishing and painting. These defects, therefore, are limited in the new sorting classification, and proposed ranges of sorting groups are related to the effect of the defect on the final product. The proposed sorting method is more precise than previous grading systems because the factors that affect the final product are considered when grading SDP.

References

Bayatkashkoli A., Amiri S., Faezipour M., Dosthosyne K. [2008]: Economical classification of small-diameter poplar utilization in the particle board and ply wood industries. Pajouhesh Sazandegi 81 [4]: 87-99

Becker D. [1998]: Lumber recovery from small diameter ponderosa pine in northern Arizona. General Technical Report. USDA Forest Service, Pacific Northwest Research, Portland, Oregon

Bodig J., Jayne B. [1989]: Mechanics of Wood and Wood Composits. Van Nostrand Reinhold, House & Home. New York

Craft E.P. [1982]: The effect of saw bolt length on the yield of pallet materials from small-diameter hardwood trees. Res. Pap. NE-499. USDA Forest Service, Northeastern Forest Experiment Station, Broomall, Pennsylvania

Craft E.P., Emanuel D.M. [1981]: Yield of pallet cants and lumber from hardwood pole timber thinnings. Res. Pap. NE-482. USDA Forest Service, Northeastern Forest Experiment Station, Broomall, Pennsylvania

Edund J., Lindstrom H., Nilsson F., Real M. [2006]: Modulus of elasticity of Norway spruce saw logs vs structural lumber grade. Holz als Roh- und Werkstoff 64: 273-279

Erikson R., Gorman T., Green D., Graham D. [2000]: Mechanical grading of lumber sawn from small-diameter lodgepole pine, ponderosa pine, and grand fir trees from northern Idaho. Forest Products Journal 50 [7-8]: 59-65

Fahey T.D., Hunt D.I. [1972]: Lumber recovery from douglas-fir thinnings at a bandmill and two chipping canters. RP-PNW-131. USDA Forest Service, Pacific Northwest Station, Portland

Fernandez-Golfin J.I., Diez-Barra M.R., Hermoso E., Mier R. [2007]: Mechanical characterization of visually classified, small-diameter laricio pin round timber. Spanish Journal of Agricultural Research 5 [3]: 304-311

Hecker M., Ressmann J., Becker G., Merforth C. [2000]: Prognosis of sawn timber quality based on roundwood grading-comparison of selected national and European grading rules for roundwood and sawn timber. Holz als Roh- und Werkstoff 3: 55

Howard J.L. [2001]: U.S. timber production, trade, consumption and price statistics 1965-1999. Res. Pap. FPL-RP-595. USDA, Forest Service, Forest Product Laboratory, Madison, Wisconsin

Michael J., De Lasaux M.J., Spinelli R., Hartsough B.R., Magagnotti N. [2009]: Using a small-log mobile sawmill system to contain fuel reduction treatment cost on small parcels. Small Scale Forestry 8: 367-379

Paun D., Jackson G. [2000]: Potential for expanding small-diameter timber market – assessing use of wood posts in highway applications. General Technical Report FPL-GTR-120. USDA, Forest Service, Forest Product Laboratory, Madison, Wisconsin

Perkins B., Smith B., Araman P.h. [2008]: Analyzing the feasibility of utilizing small diameter hardwood timber for solid wood products and residues. General Technical Report SRS-111. USDA Forest Service, Southern Research Station, Asheville, North Carolina

Petutschnigg A.J., Katz H. [2005]: A log linear model to predict lumber quality depending on quality parameters of logs. Holz als Roh- und Werkstoff 63: 112-117

Ranta-Maunus A. [1999]: Bending and compression properties of small diameter round timber. FIN-02044 VTT. VTT Building Technology, Espoo, Finland

Rast E.D., Sonderman D.L., Gammon G.L. [1973]: A guide to hardwood log grading. Revised. General Technical Report GTR-NE-1. USDA Forest Service, Northeastern Forest Experiment Station, Upper Darby, Pennsylvania

Spinelli R., Magagnotti N., Nati C. [2011]: Work quality and veneer value recovery of mechanized and manual log-making in Italian poplar plantations. European Journal of Forest Research 130: 737-744

Wang S.Y., Chen J.H., Tsai M.J., Lin C.J., Yang T.H. [2008]: Grading softwood lumber using nondestructive techniques. Journal of Materials Processing Technology 208: 149-158

Willits S., Ross R. [2004]: Veneer recovery from small diameter stands in southwestern Oregon. USDA Forest Service, Pacific Northwest Research Station and Forest Products Laboratory, Oregon

List of standards

APA-PS1-95: 1995 National Institute of Standards and Technology (NIST) construction and industrial plywood. American Plywood Association

BS EN 14081-2: Timber structures. Strength graded structural timber with rectangular cross section. Machine grading; additional requirements for initial type testing

DIN 4074-1: Strength grading of wood - Part 1: Coniferous sawn timber

EN 338, CEN: 2003 European Committee for Standardization [CEN] – Structural timber – strength classes

ISIRI Number 1275: 1994 Institute of Standards and Industrial Research of Iran – acceptable defects for logs (and gradation)

PR EN 14544: Timber structures - Strength graded structural timber with round cross-section – Requirements

VPS-SRT-2: Structural round timber – grading – requirements for visual strength – grading standards