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Characterization of ripsaw kerf for edge-glueing hardwood strips – Final Report

by

Carl Tremblay
Research Scientist
Value-added Products

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Carl Tremblay	Torsten Lihra	Gérald Beaulieu
Project Leader	Reviewer	Manager

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Abstract

Mill visits to manufacturers and users of edge-glued panels were conducted in order to characterize the quality of edge-glued joints in appearance products. During these visits, panels with gluelines of good and poor quality were collected for further analysis in Forintek's laboratory. Microscopic measurements served to determine that the maximum acceptable width of glue joints in edge-glued panels is 0.05 mm. The main causes of troublesome gluelines resulting from ripping operations are splintering at the juncture of the edge and flat surface, excessive edge roughness, and uneven straightness of the saw kerf, although the right angle of the saw is also a critical parameter. The percentage of mill-rejected panels as a result of these problems ranges from 0.5% to 3%.

A series of edge roughness measurements taken from a sample of strips from participating mills set the stage for the development of representative roughness values for the edges of strips used in the industrial production of edge-glued panels. Edge roughness measurements taken from strips ripped in the laboratory showed the impact of various factors on edge roughness values: saw blades, feed speed and chip load. Measurements taken from edges ripped with worn saw blades indicated that edge roughness cannot be used to determine saw blade wear values because average roughness values obtained with such blades were found to be similar to those of strips ripped with well-sharpened saws.

Following the laboratory assembly of panels using strips exhibiting a wide range of edge roughness, measurements revealed that edge roughness contributes to increased glueline width, a greater proportion of gluelines wider than 0.05 mm (too apparent) and a reduction in glueline shear strength. Glueing parameters (type of glue, clamp pressure, ambient temperature, etc.) were constant throughout the production of laboratory panels.

Finally, the results of this study suggest that edge roughness values of 9 µm for R_a and 80 µm for R_t allow large-volume manufacturing of panels with good quality gluelines and that an increase in edge roughness will result in more apparent gluelines.

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1 Objectives

The long-term objective of this project is to promote the optimal use of available raw material. Specific objectives include: 1) the characterization of good quality edge-glueing in appearance products (furniture); and 2) the characterization and evaluation of specific edge surface parameters contributing to good quality gluelines.

2 Introduction

The majority of massive-wood furniture components are manufactured from edge-glued panels. The manufacturing process is part of the secondary processing chain: planing, ripping and trimming of rough lumber. These operations result in strips of variable widths which, when edge-glued, form solid-wood panels. Saw kerf quality determines whether edge-glueing can proceed without edge planing. The type of saw used is usually a straight line rip saw. These saws can have one or more fixed saw blades and produce an edge of high enough quality for edge-glueing panel strips. On the other hand, the fixed distance between saw blades can result in a waste of wood. Ripsaws with moveable saw blades, which are still used on a small scale in the industry, generate a better product yield.

The parameters describing the quality of gluelines between strips are not known. This project was intended to determine these parameters and to develop a range of values. The project was also intended to allow equipment manufacturers to supply equipment capable of producing good glueing surfaces and to encourage panel manufacturers to adapt their practices in order to meet the criteria for quality edge-glueing. This will allow manufacturers to increase product recovery and value and reduce the downgrading of certain by-products.

3 Background

The issue and the objectives described above led to a two-year project (April 2003 to March 2005) designed and planned by Forintek's Value-added Products Department.

4 Staff

Carl Tremblay, Research Scientist
Torsten Lihra, Research Scientist
Marcel Lefebvre, Industry Advisor
Martin O'Connor, Technician
Francine Côté, Technician
Chantal Nadeau, Technician

5 Materials and Methods

The project was divided into two parts in order to meet the specific objectives stated above: the characterization of good quality edge-glueing; and the characterization of kerf quality for good edge-glueing.

Definition of good quality edge-glueing

A survey of manufacturers and users of edge-glued panels was conducted to determine their perception of a good glueline. In the course of mill visits, panels with good and poor quality gluelines were collected for further analysis in Forintek's laboratory. Microscopic measurements were taken in order to establish a range of values specific to gluelines of acceptable and unacceptable quality (Figure 1). The average width of a glueline was determined on the basis of ten (10) readings at 20 mm intervals along a glueline. Measurements were taken on a sample of 40 panels.

The following mills were visited as part of the survey:

- Baronet, Sainte-Marie (Que.)
- Giguère et Morin, Saint-Félix-de-Kingsey (Que.)
- Groupe Savoie, Saint-Quentin (N.B.)
- Meuble Idéal Ltée, Saint-Charles-de-Bellechasse (Que.)
- Le Meuble Villageois inc., Saint-Benoît (Que.)
- Morigeau Lépine, Saint-François (Que.)
- Cuisine Option, Québec (Que.)
- Roxton, Waterloo (Que.)
- Shermag mills in:
    - Disraëli (Que.)
    - Edmundston (N.B.)
    - Granby (Que.)
    - Saint-Étienne (Que.)
    - Saint-François (Que.)
    - Sainte-Gertrude (Que.)
    - Victoriaville (Que.)

Figure 1 Microscopic measurement of glueline width

Determination of saw kerf quality

Work specific to this section aimed to evaluate the effect of strip edge roughness on the quality of panel gluelines.

5.1.1 *Edge roughness*

Measurements of surface roughness were taken at Forintek's Structures Laboratory. Readings were taken with an electronically amplified stylus sensor (Mitutoyo SJ-400, Figure 2). This instrument reproduces and amplifies the roughness of all types of surfaces using a probe sensor (a fine diamond point) which measures and records the relief of a given surface over a certain distance. The instrument generates a graph of the amplified profile of the sensor's vertical displacement. It also directly calculates the value of the arithmetic mean deviation of surface roughness, R_a, and the peak-to-valley height, R_t, of surface irregularities. Figures 3 and 4 illustrate the geometric significance of R_a and R_t.

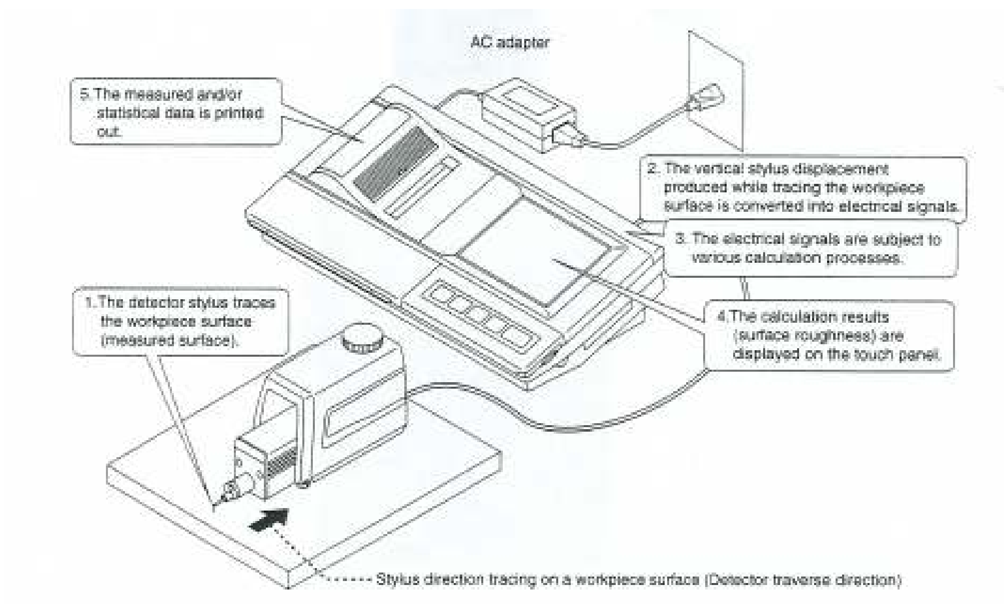

Figure 2 Stylus probe profilometer

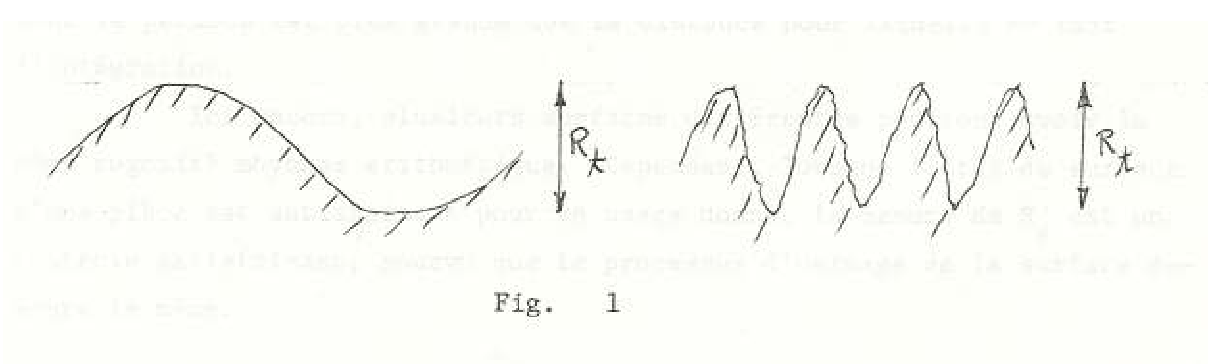

Figure 3 Geometric significance of R_t

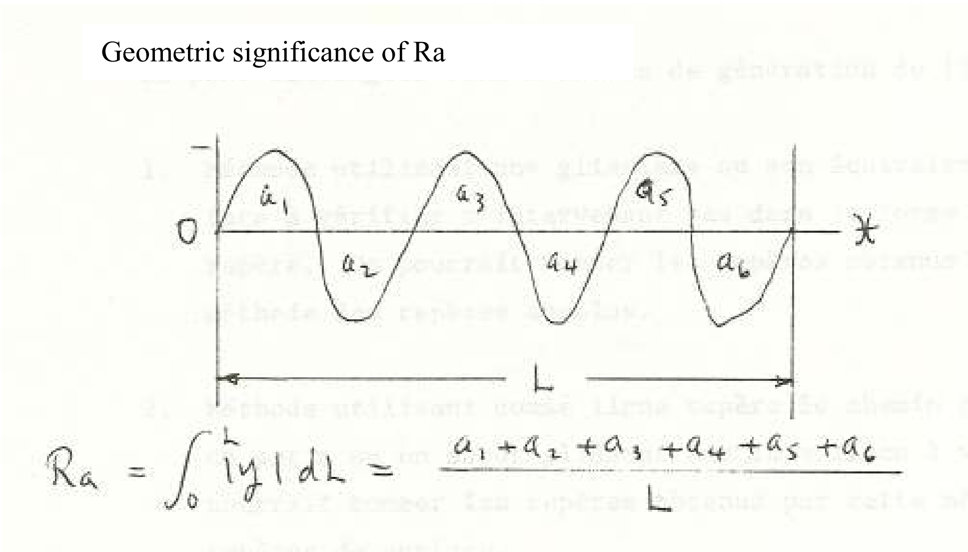

Figure 4 Geometric significance of R_a

5.1.1.1 *Laboratory-ripped strips*

Strips measuring 60 cm in length by anywhere from 3.5 to 6.5 cm in width were produced with a ripsaw in Forintek's laboratory. Strips were produced from 4/4 (1 in.) dry yellow birch sapwood No. 1 Com lumber. A Raimann KR310 ripsaw with two moving blades was used (Figure 5). Ripsawing was conducted to obtain edge roughness variability. To this end, several saw blades were used with different feed speeds as indicated in Table 1.

Figure 5 Raiman KR310 multiple blade ripsaw

Table 1 Saws used for ripping strips in the laboratory

Scenario	Saw Blade	State	Diameter (in.)	No. of Teeth	Feed Speed (ft/min.)	Chip Load (in.)
1	Glue joint quality	new	11.75	36	100	0.008
2	Glue joint quality	worn	11.5	28	78	0.008
3	Glue joint quality	worn	11.75	36	100	0.008
4	Glue joint quality	new	10.0	30	160	0.015
5	Glue joint quality	new	10.0	30	120	0.011
6	Glue joint quality	new	10.0	30	85	0.008
7	Ripping	new	10.0	24	125	0.015
8	Ripping	new	10.0	24	67	0.008

The glue joint quality blades used in scenarios 1 and 4 were provided by two saw manufacturers. Ripping was performed at each blade manufacturer's recommended feed speed for strip edge-glueing. The manufacturer of the scenario 1 saw blade recommended a feed speed of 100 to 120 ft/min. based on the characteristics of the wood and ripsaw used. The chip load corresponding to the 100 ft/min feed speed is 0.008 in. The manufacturer of the scenario 4 saw blade recommended a chip load of 0.014 to 0.020 in. at feed speeds ranging between 160 and 210 ft/min. The maximum feed speed of the laboratory ripsaw only allowed a chip load of 0.015 in.

Ripping scenarios 2 and 3 involved the use of worn glue joint quality blades. The scenario 2 saw blade was provided by a furniture manufacturer; it had about 15 hours of wear. The scenario 3 saw was provided by a saw manufacturer. It had only been used for a few trials and exhibited little wear. The ripping feed speed for these two scenarios was adjusted to maintain the scenario 1 chip load value of 0.008 in.

For scenarios 4, 5 and 6, the same glue joint quality saw blade was used at feed speeds generating a chip load ranging from 0.015 to 0.008 in.

Finally, for scenarios 7 and 8, a ripping saw blade was used in order to rip the strips with a chip load of 0.015 and 0.008 in. respectively.

Each scenario depicted in Table 1 involved ripping a set of 20 strips in the laboratory. Edge roughness measurements were taken from each strip. Each edge roughness measurement involved three readings at one-third, one-half and two-thirds of the length and the thickness of each strip.

5.1.1.2 *Mill-ripped strips*

In order to characterize the state of the strips edge-glued for the production of panels in a mill setting and to establish a baseline with respect to laboratory measurements, measurements of edge surface roughness were taken from strips collected during visits to the mills identified in Section 5.1. The strips were produced chiefly from yellow birch and, to a lesser extent, sugar and red maple. According to mill personnel, the quality of the collected strips was such that one could expect good quality edge-glueing.

Surface roughness measurements were taken from the two edges of a set of 36 strips, for a total of 216 roughness readings (Figure 6). As in the case of the strips ripped in the laboratory, edge roughness measurements involved three readings at one-third, one-half and two-thirds of the length and thickness of each strip.

Figure 6 Measuring edge roughness with the stylus probe profilometer

5.1.1.3 *Strips ripped with worn saw blades*

In order to characterize the edge roughness of strips ripped with worn saw blades, measurements were taken in accordance with the aforementioned protocol (one-third, one-half and two-thirds length and thickness of the strips). Measurements were taken from a sample of 20 strips from two mills. The strips were ripped with saw blades that needed replacement because of wear. Edge roughness measurements provided the opportunity to evaluate the effect of saw wear on roughness values. Although laboratory ripping scenarios 2 and 3 (Table 1) included the use of a worn saw blade, edge surface quality did not suggest advanced saw blade wear.

5.1.2 *Panel glueline width*

Strips ripped in accordance with the parameters of 1, 2, 4 and 7 specified in Table 1 were used to assemble edge-glued panels in the laboratory. Strips resulting from these scenarios were chosen because they exhibited a broad range of edge roughness, the values of which are presented in section 6.2.1. As a result, it was possible to determine the effect of edge surface roughness on the quality of panel gluelines in terms of glueline width. For each ripping scenario, some 20 panels measuring 20 in. wide and 24 in. long were assembled. The panels were edge-glued in the laboratory using the press illustrated in Figure 7. Glueing was completed as indicated in Table 2.

Figure 7 Panel glueing unit

Table 2 Laboratory glueing parameters

Pressure at the glueline	200 psi
Glueing time (under pressure)	1 hr
Glue thickness on strip edges	0.008 in.
Distance between clamps (centre-to-centre)	8 in.
No. of clamps (panels 24 in. long)	3
Glue type	Nacan 40-025A

Following edge-glueing of the panels in the laboratory, microscopic measurements of glueline width were taken from the four sets of 20 panels. The evaluation of glueline width was systematically achieved by measuring the width of four gluelines at predetermined positions using 10 readings at 2 cm intervals per glueline. This meant taking 40 glueline width readings from four different gluelines on each panel.

5.1.3 *Glueline shear strength*

In order to evaluate the quality of the gluelines of panels assembled in the laboratory and the effect of strip edge roughness on glueline quality, the shear strength of each set of panels was determined. Glueline shear strength was determined in accordance with the provisions of the NLGA's special products standard entitled *SPS 5-2003 Special Products Standard for Face-Glued Lumber*. For each of the four groups of panels, glueline shear strength was determined for a sample of five panels and two readings from four different gluelines for a total of 40 readings per set.

6 Discussion

Definition of good quality edge-glueing

6.1.1 Maximum acceptable glueline width

Based on measurements of glueline width taken in Forintek's laboratory on a sample of 40 edge-glued panels collected from participating mills, 0.05 mm is considered to be the maximum acceptable glueline width in edge-glued panels. In fact, gluelines wider than 0.05 mm in edge-glued panels were considered to be too apparent, and thus unacceptable, by mill personnel.

Figures 8 to 13 show edge-glued panels rejected because their gluelines are too apparent. These figures also show the major causes for panel rejection by the participating mills: splintering at the juncture of the edge and the wide face of a strip (Figures 8 and 9), excessive edge roughness or insufficient clamp pressure (Figures 10 and 11) and uneven straightness of the saw kerf (Figures 12 and 13). Measurements taken from the panels exhibiting splintering revealed the presence of cavities measured anywhere from 0.08 to 0.8 mm at the point of splintering. Glueline thickness on panels exhibiting excessively apparent gluelines over too great a length because of excessive edge roughness or insufficient clamp pressure ranged from 0.07 to 0.15 mm. Finally, panels rejected because of an uneven straightness of the saw kerf exhibited openings measuring from 0.35 to 0.82 mm.

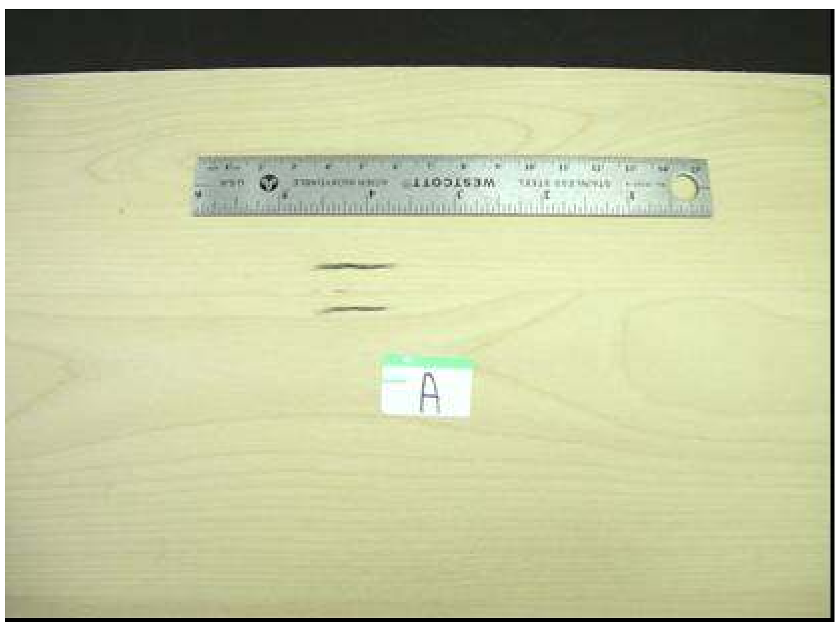

Figure 8 Apparent glueline: splintering of the edge, 0.6 mm cavity

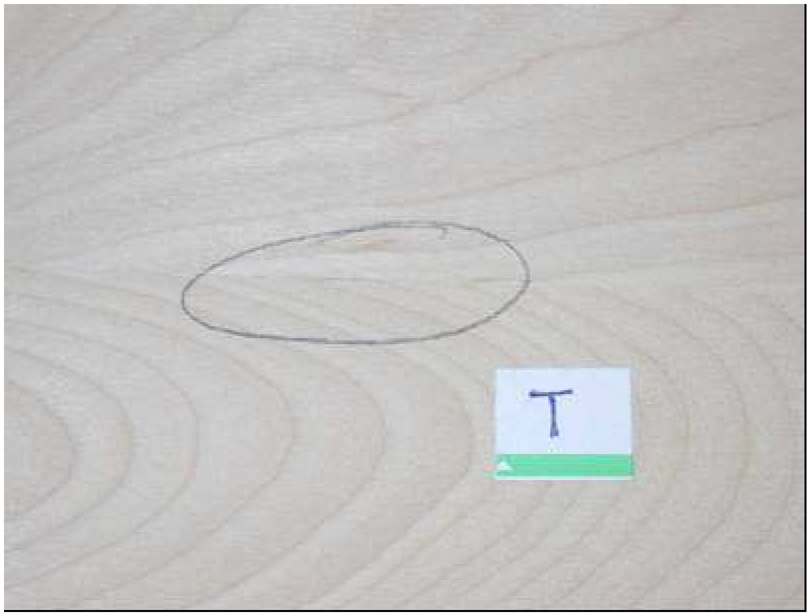

Figure 9 Apparent glueline: splintering of the edge; 0.08 mm cavity

Figure 10 Apparent gluelines: excessive edge roughness or insufficient clamp pressure; glueline width 0.07 to 0.15 mm

Figure 11 Apparent gluelines: excessive edge roughness or insufficient clamp pressure; glueline width 0.08 mm

Figure 12 Apparent glueline: uneven saw kerf straightness; max. opening 0.82 mm

Figure 13 Apparent glueline: uneven saw kerf straightness; max. opening 0.79 mm

6.1.2 *Industrial strip ripping and panel glueing*

During the course of each visit to participating mills, the project team collected technical information specific to the lumber ripping and panel glueing processes, ripping saw kerf quality and the proportion of rejected panels because of poor quality gluelines. Most of the mills use a single-blade for ripping strips of variable width. In most cases, mills use Mattison 202 and 404 straight line ripsaws with a feed speed ranging from 50 to 120 ft/min., depending on lumber species and thickness. Some mills, however, use multiple blade ripsaws. After ripping, kerf quality is determined only by a visual check. Diamond-shaped kerf marks are considered to be an indicator of subsequent good bonding quality. In mills, changing ripsaw blades occurs when the diamond saw tips are completely worn down or when strip edges exhibit glazing or machine burn. A change in the sound made by the ripsaw can also signal the need to change blades. Other mills change blades at regular intervals. The average period between blade changes varies significantly from one mill to another, depending on the lumber species used to produce panel strips. The observed period in participating mills ranged from 25 to more than 400 hours.

All the mills visited used spider-type glueing units (modular rotating clamps) except one. The exception used a steam-heated plate unit and a UF adhesive. In the case of spider-type units, hydraulic motor pressure for clamping purposes varied from approximately 750 psi for 4/4 panels to 1500 psi for 8/4 panels. Clamp pressure, measured with a proven ring gauge, ranged from approximately 50 to 95 psi for 4/4 and 8/4 panels respectively. Most mills use a PVA adhesive. At the participating mills, adhesive coat thickness on strip edges ranged from 0.007 to 0.014 in. Finally, according to mill technical data collected during mill visits, the duration of panel clamping varied ranged from 40 min. to 3 hrs and panels were stored for periods of 8 to 24 hours prior to planing.

According to comments by mill personnel or quality control reports obtained in the course of mill visits, the panel rejection rate due to faulty gluelines following glueline ripping ranged from 0.5 to 3.0%. It should be noted that people do not seem to be too concerned about faulty gluelines (open joint, splintering) and do not consider ripping to be the cause of critical problems. On the other hand, the situation is different with respect to end splits and open-end gluelines. Certain mills reported reject rates for maple panels of more than 10% and even 20% for end splits and open-end gluelines (Figure 14). These problems are caused by the lumber-drying process and shrinkage across strip width. Ripping lumber with an excessive moisture content or excessively dry mill operating conditions can also cause these problems.

Figure 14 Apparent gluelines: open-end gluelines

6.2 *Characterization of saw kerf quality*

6.2.1 *Edge roughness*

Table 3 lists the average edge roughness values for R_a and R_t measured from the sample of 20 strips ripped in the laboratory in accordance with each scenario listed in Section 5.2.1.1. Table 3 also shows average edge roughness values measured on the sample of 36 strips collected at participating mills (Section 5.2.1.2) as well as R_a and R_t readings taken from a sample of 20 mill-ripped strips using worn saw blades (Section 5.2.1.3).

Laboratory-ripped strips
The results presented in Table 3 show that the various ripping scenarios and feed speeds used for ripping strips in the laboratory generated a wide range of edge roughness values. The minimal edge roughness was obtained with a new glue joint quality saw blade at a feed speed resulting in a chip load of 0.008 in. (Scenario 1). Maximum roughness was obtained with a new ripping saw blade at a feed speed resulting in a chip load of 0.015 in. (Scenario 7). The results shown in Table 3 also lead to the following observations:

a) for scenarios 1 and 4, feed speed had been adjusted in accordance with each saw manufacturer's recommendations. Results nonetheless show a significant deviation of R_a and R_t roughness values;
b) for scenarios 4, 5 and 6 on one hand and scenarios 7 and 8 on the other, results indicate that reducing feed speed of chip load lowers edge roughness values;
c) in all cases, R_a and R_t values exhibit relatively high standard deviation, indicating significant variations in these values based on roughness readings taken from ripped strips for a given scenario.

Mill-ripped strips

R_a and R_t values obtained from mill-ripped strips fall within the range of values obtained in the laboratory using glue joint quality saw blades.

Strips ripped with worn saw blades

Following a visual examination, the edge of the strips ripped with worn saw blades exhibited the following characteristics: variable surface quality, from glazed sections to torn grain; sections with machine burn; sections with diamond-shaped marks; sections with wavy edges (juncture of the edge and wide face of a strip). These characteristics can all be found on the edge of a single strip. Edge roughness can therefore be quite variable. In fact, a glazed section can exhibit roughness R_a and R_t values as low as 3 µm and 25 µm respectively. At the other end of the scale, a section with torn grain can exhibit R_a and R_t values as high as 20 µm and 210 µm respectively.

Table 3 shows the average R_a (7.00 µm) and R_t (66.53 µm) values of a sample of 20 strips from two mills: mill A with 12 strips, average values for R_a = 6.25 µm and R_t = 54.32 µm; mill B with 8 strips, average values for R_a = 8.28 µm and R_t = 87.47 µm. The edges of strips from mill B exhibited the effects of ripping with a worn saw blade. However, the measured R_a and R_t values fall within the range of the values measured in the laboratory on strips ripped with well-sharpened glue joint quality saw blades with a chip load of 0.008 in. (scenarios 1 and 6). These observations show that the need to replace ripsaw blades because of pronounced wear cannot be determined from wood strip edge roughness.

Figure 15 Edges of strips ripped with used saw blades

Table 3 Strip edge roughness values

Laboratory-ripped strips								
Scenario	**Saw Blade**	**State**	**Diameter (in.)**	**No. of Teeth**	**Feed Speed (ft/min.)**	**Chip Load (in.)**	**R_a (µm)**	**R_t (µm)**
1	Glue joint quality	new	11.75	36	100	0.008	**6.51** *(2.36)*	**73.74** *(25.87)*
2	Glue joint quality	worn	11.5	28	78	0.008	**9.54** *(3.36)*	**88.00** *(30.07)*

Laboratory-ripped strips								
Scenario	**Saw Blade**	**State**	**Diameter (in.)**	**No. of Teeth**	**Feed Speed (ft/min.)**	**Chip Load (in.)**	**R_a (µm)**	**R_t (µm)**
3	Glue joint quality	worn	11.75	36	100	0.008	**7.31** *(3.10)*	**78.85** *(30.61)*
4	Glue joint quality	new	10.0	30	160	0.015	**10.92** *(3.24)*	**110.33** *(33.57)*
5	Glue joint quality	new	10.0	30	120	0.011	**8.77** *(3.24)*	**88.67** *(32.34)*
6	Glue joint quality	new	10.0	30	85	0.008	**9.19** *(3.59)*	**88.32** *(26.70)*
7	Ripping	new	10.0	24	125	0.015	**13.19** *(3.70)*	**116.82** *(31.29)*
8	Ripping	new	10.0	24	67	0.008	**11.82** *(2.92)*	**98.85** *(23.78)*
Mill ripped strips							**8.73** *(2.23)*	**79.87** *(19.94)*
Strips ripped with used saw blades							**7.00** *(2.83)*	**66.53** *(30.64)*

6.2.2 *Glueline width in relation to edge roughness*

Glued panels assembled from laboratory-ripped strips
Strips ripped in accordance with the parameters of ripping scenarios 1, 2, 4 and 7 specified in Table 1 were used to assemble edge-glued panels in the laboratory. Table 4 shows the results of glueline width measurements for each set of panels. Glueline width measurements were taken at predetermined positions along the glueline of each panel. Panels were assembled in accordance with the glueing parameters mentioned in Section 5.2.2.

For each ripping scenario, Table 4 shows the number of assembled panels, the number of gluelines measured (four per panel), the average glueline width and standard deviation, and the proportion of gluelines with an average width greater than 0.05 mm, that is, the value considered to be the maximum acceptable width on the basis of the results listed in Section 6.1.1.

The results shown in Table 4 suggest that an increase in edge roughness results in an increase in glueline width. The same holds true for the proportion of gluelines with a width greater than 0.05 mm: the proportion of gluelines that are too apparent increases with edge roughness. Figure 16 illustrates these observations.

It should be noted that the proportion of gluelines with a width greater than 0.05 mm in Table 4 may seem to be high and lead to a higher reject rate under commercial production conditions. It is important to remember that these are microscopic measurements and that gluelines with an average width of 0.055 mm (a significant proportion) were therefore classified as too apparent in the laboratory.

Table 4 Average glueline width of laboratory edge-glued panels

Scenario	Saw Blade	R_a (µm)	R_t (µm)	No. of Panels	No. of Gluelines	Average Width (mm)	Standard Deviation (mm)	% Gluelines > 0.05 mm (%)
1	Glue joint quality	6.51	73.74	**20**	**80**	**0.035**	**0.011**	**2.5**
2	Glue joint quality	9.54	88.00	**18**	**72**	**0.034**	**0.011**	**5.6**
4	Glue joint quality	10.92	110.33	**20**	**80**	**0.039**	**0.011**	**8.8**
7	Ripping	13.19	116.82	**20**	**80**	**0.042**	**0.012**	**15.0**

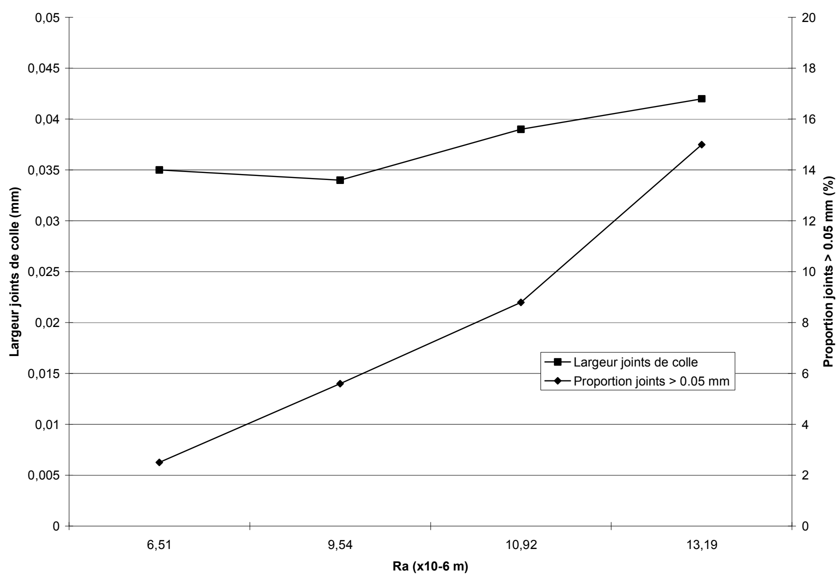

Figure 29 Average glueline width and proportion of gluelines >0.05 mm with relation to R_a

Panels assembled from mill-ripped strips produced with worn saw blades

Four panels were edge-glued in the laboratory using mill-ripped strips produced with worn saw blades. Glueing parameters are indicated in Section 5.2.2. For each panel, glueline width measurements were taken from three gluelines and ten readings were taken from each glueline. The average glueline width of the 12 gluelines measured on the four panels was 0.048 mm with a standard deviation of 0.012 mm. The average glueline width is therefore slightly under the maximum acceptable limit of 0.05 mm. However, the width of two gluelines was 0.06 mm or greater. It is important to remember that although the edge-glued strips were ripped with worn saw blades, the edge roughness values for these strips were within the range of values for strips ripped with recently sharpened glueline quality saw blades.

For the purposes of comparison, it should be noted that the average edge roughness values for strips ripped with used saw blades (R_a = 7.00 and R_t = 66.53) are similar to the values for the scenario 1 strips ripped in the laboratory (R_a = 6.51 and R_t = 73.74). The measured values show that the average glueline width was 37% greater for panels assembled from strips ripped with worn saw blades.

To conclude, edge-glueing strips ripped using saw blades exhibiting a high degree of wear, that is, saw blades that need to be replaced according to criteria used at participating mills, can result in gluelines of acceptable width. However, the width of a significant proportion of gluelines will exceed the maximum acceptable limit of 0.05 mm.

6.2.3 *Shear strength with relation to edge roughness*

Glued panels assembled from laboratory-ripped strips
Table 5 shows the results obtained from glueline shear strength measurements for the four sets of panels assembled with strips produced in accordance with ripping scenarios 1, 2, 4 and 7. For each panel, 8 shear strength measurements were taken from four gluelines (two measurements per glueline) at predetermined positions. The measurements were taken from a sample of 5 panels per set.

For each ripping scenario, Table 5 shows shear strength and standard deviation values. The results show that glueline shear strength decreases as strip edge roughness increases (see Figure 17_.

Table 5 Average glueline shear strength of laboratory edge-glued panels

Scenario	Saw Blade	R_a (µm)	R_t (µm)	Average Glueline width (mm)	% Gluelines > 0.05 mm (%)	Shear Strength (MPa)	Standard Deviation (MPa)
1	Glue joint quality	6.51	73.74	0.035	2.5	**19.903**	**2.454**
2	Glue joint quality	9.54	88.00	0.034	5.6	**18.655**	**1.934**
4	Glue joint quality	10.92	110.33	0.039	8.8	**19.066**	**2.318**
7	Ripping	13.19	116.82	0.042	15.0	**17.317**	**2.334**

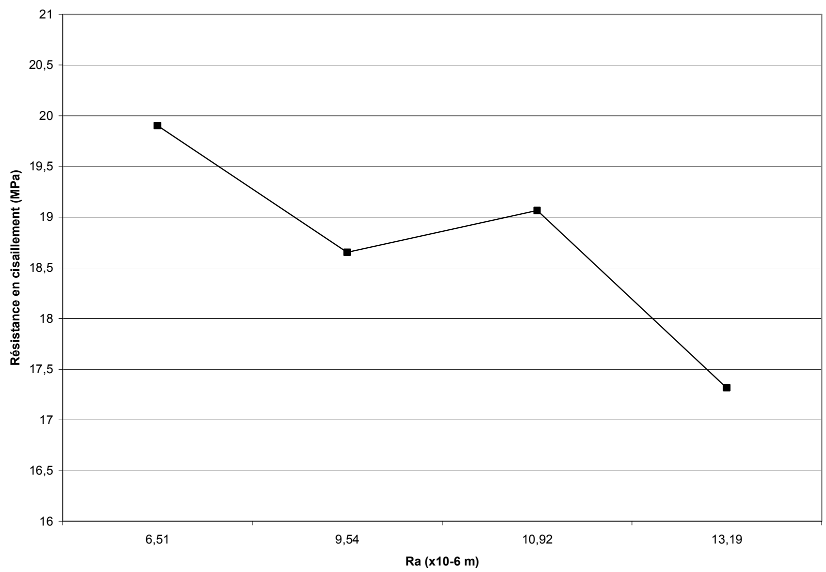

Figure 17 Glueline shear strength in relation to R_a

Panels assembled from mill-ripped strips produced with used saw blades
Table 6 shows the results of glueline shear strength measurements taken from four edge-glued panels assembled from mill-ripped strips produced with used saw blades. For each panel, six shear strength measurements were taken from three gluelines (two measurements per glueline).

Table 6 shows average values of strip edge roughness, panel glueline width and shear strength, and the standard deviation. For the purposes of comparison with values measured on panels produced under ripping scenario 1 and similar R_a and R_t values, measured values show that the average glueline shear strength of panels assembled from strips ripped with worn saw blades is 13% lower. This is statistically significant. However, a shear strength value of 17.337 MPa is more than adequate for non-structural applications, such as furniture components.

Table 6 Average glueline shear strength of laboratory edge-glued panels

Saw Blade	R_a	R_t	Average Glueline Width (mm)	Shear Strength (MPa)	Standard Deviation (MPa)
Worn (mill-ripped strips)	7.00	66.53	0.048	**17.337**	**1.745**

7 Conclusions

With respect to the first objective of this project, that is, the definition of a good quality glueline for appearance products, measurements of glueline widths in the laboratory on panels deemed to be acceptable and unacceptable by the staff of 15 participating mills led to the conclusion that 0.05 mm was the maximum acceptable glueline width for edge-glued panels.

With respect to the second objective of this project, it was found that edge roughness, saw kerf straightness and splintering along the edges are the major factors affecting the quality of panel gluelines. The right angle of the saw is also a critical factor. On the basis of measurements taken from mill-ripped strips, R_a and R_t edge roughness values of 9 µm and 80 µm respectively allow the manufacture of large volumes of panels with good quality gluelines. On the other hand, an increase in edge roughness will result in more apparent gluelines.

The results obtained in the course of this project have led to the following observations:

Edge roughness
A series of measurements of the edge roughness of a sample of strips from participating mills set the stage for the development of representative edge roughness values for strips used in the industrial production of edge-glued panels: R_a = 8.73 µm and R_t = 79.87 µm.

Edge roughness measurements taken from strips ripped in the laboratory showed the impact of the saw model and feed speed on edge roughness values. Thus, ripping strips with two glueline quality saw blades at feed speeds recommended by their manufacturers resulted in differences in the R_a and R_t values of 68% and 50% respectively.

Measurements of strip edge roughness showed that ripsaw feed speed can lower edge roughness.

Measurements of the edge roughness of strips ripped with used saw blades showed significant variations by a factor of eight of the R_a and R_t values, depending on the state of the wood surface. However, measured average roughness values fall within the range of the measured values from strips ripped with well-sharpened glueline quality saw blades. Thus, strip edge roughness (average values) is not an indicator of the degree of wear of saw blades and does not allow the identification of ripping saw blades requiring replacement for a high level of wear.

Panels
Measurements of the gluelines of panels edge-glued in the laboratory showed that increased strip edge roughness leads to an increase in glueline width and of the proportion of gluelines with a width greater than 0.05 mm (too apparent). Measurements of edge roughness can therefore be used for quality control in order to prevent the presence of gluelines that are too apparent.

Edge-glueing strips ripped with used saw blades in the laboratory indicated that although gluelines with an acceptable width could be obtained, a significant proportion of gluelines with a width greater than 0.05 mm would still occur since saw blade wear leads to increased glueline width (greater variation of strip edge roughness).

Measurements of the glueline shear strength of panels edge-glued in the laboratory showed that an increase in strip edge roughness results in lower shear strength values. Despite similar edge roughness values, measurements showed that ripping strips with used saw blades results in lower shear strength values.