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# Effect of steaming time on surface roughness of beech veneer

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**Abstract**

The objective of this study was to investigate effect of steaming time on surface roughness of beech (*Fagus orientalis* L.) veneer produced using the rotary cutting method. Three roughness parameters, average roughness ($R_a$), mean peak-to-valley height ($R_z$), and maximum roughness ($R_{max}$) obtained from a stylus type profilometer were used to evaluate the roughness of the veneer sheets. Surface roughness of the samples cut from the inner portion of the logs showed a significant dependence on steaming time. Among the specimens 20 h steaming time showed the smoothest surface . Surface roughness of veneer samples taken from both outer and middle portion of the logs did not show any statistically significant difference as steaming time was changed. Based on the findings in this study, it appears that steaming time should be approximately 20 h to have an ideal surface quality of the veneer with a minimum cost of production.


*Keywords:* Veneer; Surface roughness; Steaming time

## 1. Introduction

Beech is the most abundant broadleaf tree species in central Europe and the quality of beech round wood is suitable for high quality rotary cut veneer. Veneer-based panels are manufactured in many countries and total plywood manufacture in the world is approximately 50,000,000 $m^3$ /year [1]. Veneer is produced using rotary cutting or slicing techniques for paneling, industrial parts, construction purposes, and overlaying of furniture units [2].

Heating is one of the most important processes in veneer manufacturing. Almost all hardwoods and softwoods are heated prior to cutting the veneer. Heating of the wood is usually carried out by putting the logs in a vat and applying steam to the load. The main objective of heating the logs in a steam vat is to make the wood softer and more plastic so that the log becomes pliable and more readily peeled. Reduction of knife wear and power consumption are positive results of heating. Improving the surface quality of veneer is also a significant contribution of the steaming process. Thin veneer is widely used as overlay for substrate panels such as particleboard and medium density fiberboard in furniture industry. Therefore, surface roughness of the veneer plays an important role in an efficient overlaying process. The amount of resin and press cycle are two important manufacturing parameters influenced by surface roughness of veneer. Both physical and mechanical properties of the overlaid products will also be affected by surface roughness of the veneer. For example bonding strength between overlay veneer and the substrate decreases with increasing veneer roughness [1,3]. Generally it is difficult to have a very smooth surface of veneer produced using rotary cutting method as compared to that of slicing technique. Differences in wood texture, properties of wood, cutting parameters such as knife and sharpness angle will also affect the surface quality of the veneer.

Overall roughness of veneer could be readily determined in technical terms, given a representative

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graphical or numerical reading of the surface topography. Several methods are available but have not found widespread use in the industry, and no practical standard of surface quality evaluation of veneer has come up. Standard contact measuring devices employing a stylus tracer are commonly used in metal and plastic industries. Stylus method is accurate, practical, and repeatable. Quantitative roughness parameters can be precisely calculated by this method. Parameters such as the stylus tip radius, the force produced by the stylus, and cut-off length of the profile have important effects on the accuracy of the results [4–6].

In this study, three roughness parameters were used to evaluate surface roughness of veneer steamed for different time spans and to provide information concerning optimum steaming time for logs to produce veneer sheets with smooth surface.

## 2. Material and methods

Three beech logs with an average of 45 cm diameter at breast height were cross cut into 1.5 m long sections known as bolt. Each bolt was put in a steam vat with a temperature of 65 °C. After the bolts were kept for 20 h in the vat they were rotary cut on Angelo Cremeno peeler at the speed of 30 m/min. First, the outer portion of each bolt was cut and remaining of the bolts was put into the vat for further steaming. After 40 and 60 h steaming of the bolts veneer sheets with a thickness of 1.4 mm were produced from the inner part of the sapwood and heartwood (core portion) of the bolts.

Sharpness angle and clearance angle are important parameters influencing the quality of the veneering process. The first one is the angle between back face and beveled face of the knife which determines how strong the knife is. Clearance angle refers to the angle of the cutting edge with respect to the face of knife. It determines whether the knife will cut freely and smoothly. These two angles for the cutting process were selected as 20° and 21°, respectively. Consistent pressure of the bar and peeling speed were also used to obtain a uniform veneer thickness.

Thirty veneer specimens with a length of 20 cm and width of 10 cm were cut from veneer sheets obtained from the three portions of each bolt steamed at different time. The samples were dried to 6% moisture content and conditioned in a climate chamber with a temperature of 20 °C and relative humidity of 65%. In a typical veneer cutting process, veneer side facing to the knife develops fine cracks and this side is called loose side while the opposite face is tight side. Twenty surface roughness measurements were taken from the tight surface of each sample using a fine stylus profilometer. Mitutoyo SJ-301 brand equipment was used to determine the roughness characteristics of the specimen. The equipment has a skid type diamond stylus with 5 μm tip radius and 90° tip angle. The stylus traverses the surface at a constant speed of 1 mm/s over 12.5 mm surface tracing length, converting the vertical displacement of the stylus into an electrical signal. Cut-off length is a standard roughness parameter that differentiates roughness and waviness profiles from each other. The cut-off length should be at least 2.5 times of the peak-to-peak point spacing of the profile so that at least two peaks and valleys can be included in each cut-off length through the profile [4]. Cut-off length of 0.25 mm was used for surface roughness measurements. $R_a$, $R_z$, and $R_{max}$ roughness parameters were considered to evaluate effect of steaming time on roughness characteristics of the veneer. $R_a$ is the average distance from the profile to the mean line over the length of assessment or surface tracing length. The parameters $R_a$ can be determined by the following formula.

$$R_a = 1/L_t \int_0^{Lt} y(x)/dx,$$

where $L_t$ is the surface tracing length, $R_z$ can be defined as an average of five equal consecutive peak-to-valley heights within the complete tracing length, whereas $R_{max}$ is the maximum peak-to-valley height within the profile. Specifications of these parameters were discussed in previous studies [7–11]. Figs. 1 and 2 show typical

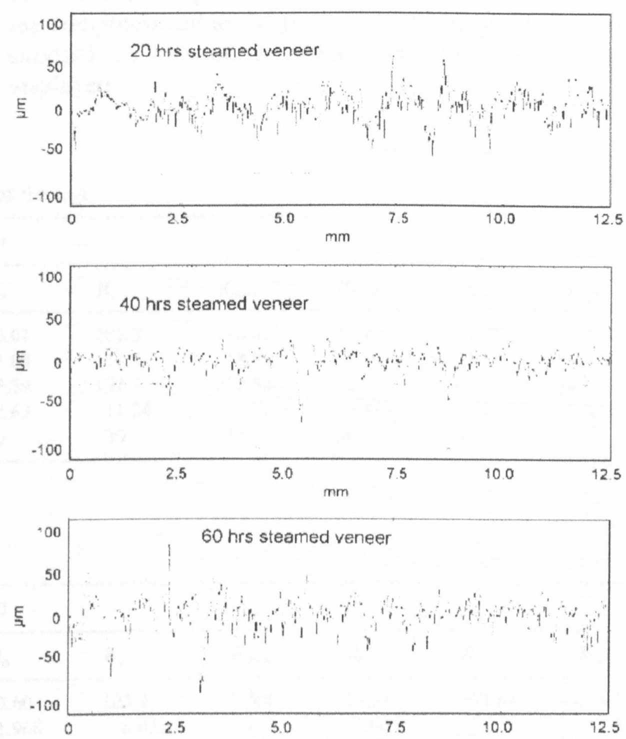


Fig. 1. Typical surface roughness of the specimens cut from the inner (heartwood) part of the logs.

surface roughness profiles of the specimens obtained from the center and outer portions of the logs steamed for different time spans.

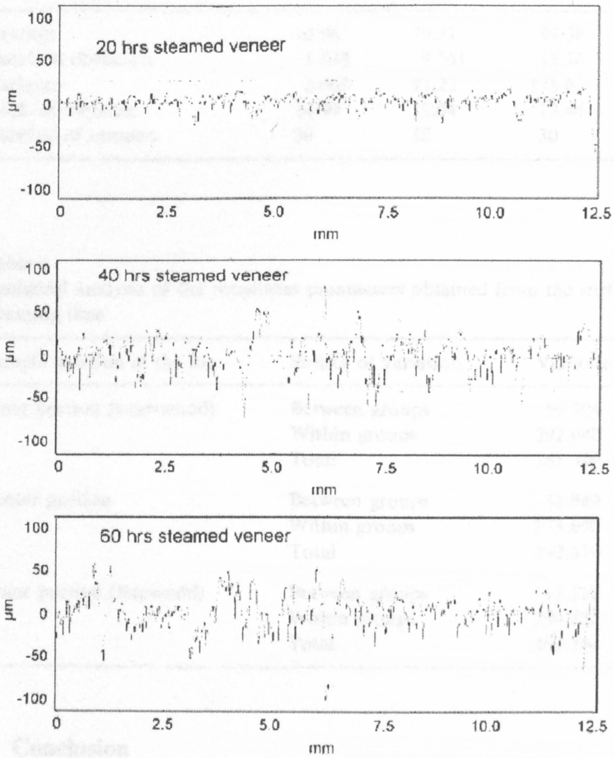


Fig. 2. Typical surface roughness of the specimens cut from the outer (sapwood) part of the logs.

## 3. Results and discussion

Tables 1–3 also show average values of the three roughness parameters taken from the surface of the samples. Overall roughness of veneer sheets taken from heartwood had higher values than those of sapwood. Extractive materials which are chemical substance in wood, not an integral part of the cellular structure that can be removed by solution in water, benzene or other solvent, in the heartwood could be responsible for rough surface of the samples taken from the inner parts of the logs. The roughness of the specimen obtained from the heartwood portion of the log increased with increasing steaming time. Steaming of 20 h resulted in the smoothest surface with average values of 13.95, 100.33, and 127.04 µm for $R_a$, $R_z$, and $R_{max}$, respectively. Table 4 show relationships between sample location in the logs and steaming time. Groups in Table 4 refers individual veneer samples cut from different section of the logs. Based on statistical analysis a significant difference was found between three roughness parameters, $R_a$, $R_z$, and $R_{max}$ function of steaming time obtained from the surface the veneer samples taken from the inner portion (heartwood) and from the center portion which are adjacent layers within the core and close to the sapwood of the logs. This could be related to possible higher level of growth stresses located in the heartwood of the logs than in the sapwood. However, no statistically significant difference was determined for the roughness values of the sapwood veneer specimens exposed to the above three steaming duration as displayed.

Table 1
Roughness values of the specimens taken from the inner part (heartwood) of the logs

| Steaming time (Hr) | 20 | | | 40 | | | 60 | | |
|---|---|---|---|---|---|---|---|---|---|
| Roughness parameter (µm) | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ |
| Average | 13.95 | 100.33 | 127.04 | 15.01 | 102.3 | 126.46 | 16.10 | 111.51 | 149.91 |
| Standard deviation | 1.96 | 14.40 | 22.03 | 1.89 | 11.5 | 14.81 | 1.50 | 12.16 | 21.40 |
| Variance | 3.87 | 207.4 | 485.62 | 3.59 | 132.3 | 219.56 | 2.26 | 147.89 | 458.36 |
| Coef. of variance | 14.10 | 14.35 | 17.34 | 12.63 | 11.24 | 11.71 | 9.33 | 10.90 | 14.28 |
| Number of samples | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Table 2
Roughness values of the specimens taken from center part of the logs

| Steaming time (h) | 20 | | | 40 | | | 60 | | |
|---|---|---|---|---|---|---|---|---|---|
| Roughness parameter (µm) | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ |
| Average | 12.04 | 86.89 | 110.28 | 13.60 | 103.9 | 129.4 | 13.18 | 95.84 | 123.2 |
| Standard deviation | 1.416 | 8.810 | 16.321 | 1.968 | 8.056 | 16.9 | 1.605 | 11.37 | 15.7 |
| Variance | 2.005 | 77.62 | 266.46 | 3.873 | 64.82 | 288.9 | 2.576 | 129.31 | 247.9 |
| Coef. of variance | 11.75 | 10.13 | 14.80 | 14.46 | 7.748 | 13.13 | 12.17 | 11.86 | 12.7 |
| Number of samples | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Table 3
Roughness values of the specimens taken from outer part (sapwood) of the logs

| Steaming time (h) | 20 | | | 40 | | | 60 | | |
|---|---|---|---|---|---|---|---|---|---|
| Roughness parameters (μm) | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ | $R_a$ | $R_z$ | $R_{max}$ |
| Average | 10.96 | 79.31 | 99.38 | 10.98 | 84.80 | 102.3 | 11.79 | 93.73 | 117.6 |
| Standard deviation | 1.633 | 9.551 | 13.36 | 1.298 | 9.860 | 15.16 | 1.662 | 9.213 | 19.1 |
| Variance | 2.669 | 91.22 | 178.6 | 1.686 | 97.23 | 230.0 | 2.764 | 84.88 | 367.0 |
| Coef. of variance | 14.90 | 12.04 | 13.44 | 11.81 | 11.62 | 14.82 | 14.09 | 9.828 | 16.2 |
| Number of samples | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

Table 4
Statistical analysis of the roughness parameters obtained from the surface of veneer samples taken from three locations of the log as function of steaming time

| Sample location in the log | Source of variation | Variance | Degree of freedom | F-ratio (95%) | Significance level |
|---|---|---|---|---|---|
| Inner portion (heartwood) | Between groups | 69.304 | 2 | 10.322⩾3.151 | S |
| | Within groups | 292.040 | 87 | | |
| | Total | 361.340 | 89 | | |
| Center portion | Between groups | 38.989 | 2 | 6.685⩾3.151 | S |
| | Within groups | 253.690 | 87 | | |
| | Total | 292.670 | 89 | | |
| Outer portion (Sapwood) | Between groups | 13.522 | 2 | 2.350⩽3.151 | NS |
| | Within groups | 250.252 | 87 | | |
| | Total | 263.744 | 89 | | |

## 4. Conclusion

In this study, surface roughness of beech veneer steamed for different times was determined using a stylus tracing method and following conclusions can be made:

(1) A fine stylus method can be effectively used to quantify and evaluate surface roughness of veneer as function of steaming time.
(2) Increasing steaming time did not influence surface roughness of sapwood veneer which is close to the outer portion of the bolts.
(3) Increased steaming time significantly increased roughness characteristics of the specimens taken from the heartwood (inner portion of the log).
(4) It was found that 20 h steaming is an ideal time in order to have smooth surface for both heartwood and sapwood portions of the veneer logs.
(5) Further study of additional parameters such as core roughness depth ($R_k$), reduced peak height ($R_{vk}$), and reduced valley depth ($R_{pk}$) could give a better understanding of the surface roughness properties of veneer steamed for various time spans. Detailed information about such parameters can be found in various works [4,10].

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