MODELING OF SAWING LOGS USING APPROXIMATED CROSS- AND LONGITUDINAL SECTION SHAPE OF LOGS. PART I. MATHEMATICAL MODEL FOR PRIMARY PROCESSING OF RESULTS OF SCANNED LOGS BY MEANS OF TWO-AXIS SCANNER AND THEIR CLASSIFICATION ACCORDING TO THE PRESENCE OF CURVE

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Abstract

A mathematical model is proposed allowing determination of curves and log shapes approximated to the ideal ones in cross-section and longitudinal-section directions. The results are based on scanning by means of two-axis scanner. The real log shape was scored by the dimensional values of the positions (P_{xi}, P_{yi}) and diameters (d_{1i}, d_{2i}) of the scanned at regular intervals cross-sections. By means of the model proposed, the cross-sections are presented in convenient manner only by a part of the values of the positions established. These are the arrows (f_{xi} and f_{yi}) measured regarding the tangent to maximum diameter or chord in the case of logs with curve and translation carried out for excluding the coordinate of the mentioned line. The results present the logs situated parallel to the applicant axis and allow determining the presence and the type of curve, as well as the shapes approximated by cross- and longitudinal sections.

Key words: *logs, positions and arrows of cross-sections, curve.*

INTRODUCTION

The current practice in simulation mathematical modeling of sawing logs to lumber by using the theory of maximum sawing patterns is based on the idealized log shape in cross- and longitudinal section directions. This fact has its background in the regular prismatic shape of the lumber and the modeling by means of mathematical rules requires regularity in the shape. Numerous methods for determining of optimal thickness of logs have been developed, including the theory of maximum sawing patterns but all they suffer of substantial deviations between the planed and actual results due to discrepancies between the idealized and the real shape of logs. Therefore, the closer the idealized shape of logs is to the actual one, the smaller the deviations. Hence, development of a process of simulation mathematical modeling of sawing logs to lumber should go through determining of the closest approximate actual shape of each log to the idealized shape.

The development of scanning technique allowed characterizing of the log cross-sections except by diameters (d_{ji}) also by their positions (P_{ji}), i.e. distances of the cross sections from the scanning line for the respective direction of scanning. These are dimensional values and presented in a general form of all cross-sections, they characterize the actual log shape.

The objective of the present study was to develop an appropriate mathematical model for processing results of logs scanned by means of two-axis scanner for further approximation of the shapes by cross- and longitudinal sections. The method further was used for determining the log curve and log volume and application of the approximated shapes in simulation modeling of sawing by using the theory of the maximum sawing patterns.

METHODS OF STUDY

The studies are based on the method of measurement of positions and diameters of logs scanned by two-axis scanner (Mongeau et al., 1993), i.e. cross-sections characterized by positions and diameters in two perpendicular directions (axes *Ox* and *Oy*), situated at equal intervals on the log length (axis *Oz*) – Figure 1.

The model proposed considers the shape of logs and the final results exclude the specificity in the positions of cross sections that are due to their situation on the transporting conveyer by their division into two parts. The first part of the positions of all cross-sections – f_{ji} is related to the log shape and it is taken into account obligatory, while the second one (*Pji-fji*), related to the situation of the log on conveyer, is excluded (Blagoev, 2004).

The cross-sections of the logs without curve are situated on an axis parallel to the axis Oz, and of these with curve – on a curve line, approximating the log shape. In both cases the part of position f_{ji} containing information about the log shape is in the dimensional value out of ordinate for the first (and abscissa for the second) direction of scanning of tangent to the maximum diameter of logs without curve and to the chord of the curve in logs with curve. This means that by reducing of values of positions to the ordinate (abscissa) or the tangent (chord), a suitable translation of a coordinate system is done and the cross-sections are characterized by the respective arrows and diameters. Thus after the primary processing of the results of dimensional values from scanning, the log shape does not change and these without curve are positioned parallel to the applicant axis, while these with curve – with chord parallel to the applicant axis.

This method of presenting unifies the cases and allows application of a methodology for determining of approximated actual to idealized log shapes by cross- and longitudinal sections.

RESULTS

The positions (P_{ji}) include ordinates y_t and abscissas x_t of projected lines tangent to the upper (closer) generant line for the first and second scanning directions, respectively, determined by the equations:

$$y_t = P_{yi} min, \qquad x_t = P_{xi} min.$$

In the case of logs without curve their positioning along the longitudinal axis parallel to the axis Oz is done by calculation of reduced positions P'_{ji} according to the formulae:

$$P'_{ji} = P_{ji} - f_{ji} = P_{ji} - (P_{ji} - y_t)/2,$$

where the values of f_{ji} are determined as follows:

$$f_{ji} = (P_{ji} - y_t)/2,$$

After the processing, the ordinates and abscissas of points of the upper generant line and situation of the longitudinal axis parallel to the axis *Oz* are expressed by formulae:

$$f_{yi} = y_t + (P_{yi} - y_t)/2, \text{ and } f_{xi} = x_t + (P_{xi} - x_t)/2,$$

and after translation of the coordinate system the final values of the ordinates and abscissas of the points of the two upper generant lines in the directions considered are:

$$y_i = (P_{yi} - y_t)/2 \text{ and } x_i = (P_{xi} - x_t)/2.$$

In the case of presence of a curve, the situation of the points determining curve chord allow determining of the angle and reduced values of P'_{ji} by means of the formulae:

$$\alpha = arctg \frac{P_{ji}\max - P_{ji}\min}{L}$$

$$P'_{yi} = y_t + (n-i)\,\Delta L\, tg\,\alpha, \quad P'_{xi} = x_t + (n-i)\,\Delta L\, tg\,\alpha,$$

where the relationship between the number and length of the cuts between the sections (n, ΔL) and intermediate number of the sections ***i*** is expressed by the equation:

$$n\,\Delta L = (i-1)\,\Delta L = L$$

After merging of the chord and tangent and after translation, the upper generant line is determined only by means of arrows, which, for logs with one-side curve, are determined by the formula:

$$y_i = f_{yi} = P_{yi} - [y_t + (n-i)\,\Delta L\, tg\,\alpha]; \; x_i = f_{xi} = P_{xi} - [x_t + (n-i)\,\Delta L\, tg\,\alpha].$$

When the curve is two-sided, after merging of the chord and applicant axis, the arrows after the tangent point at the second curve with shorter length are calculated by means of the following differences:

$$y_i = f_{yi} = P_{yi} - y_t; \; x_i = f_{xi} = P_{xi} - x_t$$

It should be noted that the abscissas and ordinates designated by a same number characterize the same cross-section and refer to the two perpendicular diameters, and have a common applicant. The coordinates of the points of the distant generant lines are equal to those of the closer ones plus the values of the respective diameters. Thus each log is characterized by coordinates of points, forming four generant lines.

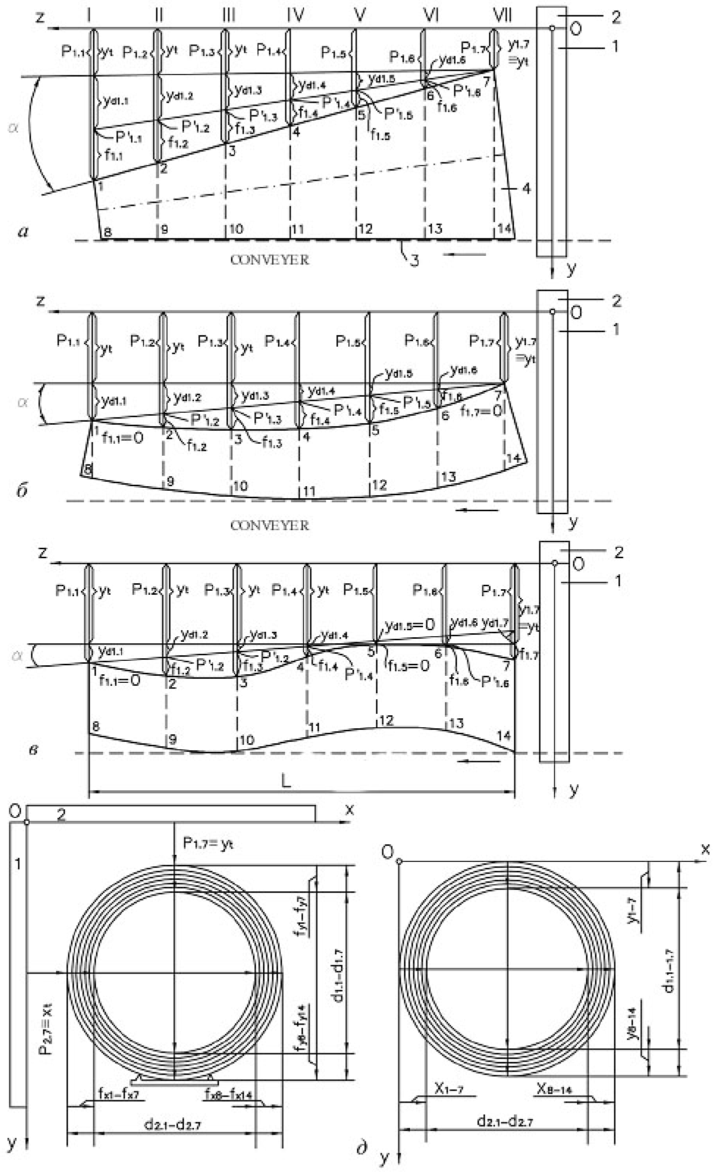

Figure 1. Scanning of logs by means of two-axis scanner and way of primary processing of the results: a, b, c – decomposition of ordinates of points of upper generant line in the case of logs without, with one- and two-side curve; d – upper (close) generant lines represented by sum of ordinates (abscissas) of tangents and arrows; e - upper (close) generant lines represented only by ordinates (abscissas) characterizing the taper curve zone.

The information about the dimensional values obtained by two-axis scanner and processed by the model proposed allow characterization and classification of the logs into following groups: 1 – without curve; 2 – with one-sided curve; 3 – with two-sided curve; 4 – with complex (multi-sided) curve. The presence and type of curve could be detected by the positions of the cross-sections. More precise information could be obtained by using the middle parts of the cross-sections (C_{1i}, C_{2i}), determined by secondary processing of results as indicated in Table 1.

Table 1. Determining the presence and type of curve by means of middle parts of the cross-sections along the scanning directions using the examples on Fig.1.

Example as in Fig. 1.	Scanning direction	Comparison of the values of middle parts of cross-sections. The type of inequality determines the type of curve.	Curve by scanning direction and generally for the logs
1a	I – by Oy II – by Ox	$C_{1.1}<C_{1.2}<C_{1.3}<C_{1.4}<C_{1.5}<C_{1.6}<C_{1.7}$ $C_{2.1}<C_{2.2}<C_{2.3}<C_{2.4}<C_{2.5}<C_{2.6}<C_{2.7}$ generally for the log	No curve No curve No curve
1b	I – by Oy II – by Ox	$C_{1.1}<C_{1.2}<C_{1.3}\cong C_{1.4}>C_{1.5}>C_{1.6}>C_{1.7}$ $C_{2.1}<C_{2.2}<C_{2.3}<C_{2.4}<C_{2.5}<C_{2.6}<C_{2.7}$ generally for the log	One-sided No curve One sided
1c	I – by Oy II – by Ox	$C_{1.1}<C_{1.2}\cong C_{1.3}>C_{1.4}>C_{1.5}<C_{1.6}>C_{1.7}$ $C_{2.1}<C_{2.2}<C_{2.3}\cong C_{2.4}>C_{2.5}>C_{2.6}>C_{2.7}$ generally for the log	Two-sided One-sided Complex

CONCLUSIONS

An original mathematical model for processing of the dimensional values obtained by means of scanning logs by two-axis scanner. The essence of the model is in decomposition of the positions of cross-sections and translation of all sections to the tangent at the cross-section at larger-end diameter of logs without curve and to the chord of logs with curve. Thus the dimensional values of positions and diameters are situated unified in the coordinate system, which allows application of a method for automated determination of the coordinates of points of four generant lines of logs and opportunity for precise determination of the actual log shape.

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