MODELING OF SAWING LOGS USING APPROXIMATED CROSS- AND LONGITUDINAL SECTION SHAPE OF LOGS. PART II. AN ALGORITHM FOR SECONDARY PROCESSING OF RESULTS OF SCANNED LOGS BY MEANS OF TWO-AXIS SCANNER AND DETERMINING OF THEIR VOLUMES AND APPROXIMATED SHAPES BY CROSS- AND LONGITUDINAL SECTIONS

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Abstract

The results of scanned logs by means of two-axis scanner consist of dimensional values of positions and diameters in two perpendicular directions characterizing cross-sections at equal intervals along their length. Generally seen, these results represent the actual log shape and allow precise determination of log volume. The paper presents methods for automated calculation of basic parameters, which make possible the log volume as a sum of volumes of smaller-length sections, as well as the approximated log shape related to the closest one among four idealized shapes, both in cross- and longitudinal section directions. This allows further to proceed to application of the approximated log shapes determined, to further develop the theory for designing of maximum sawing patterns and to remove the deviations due to the differences between the actual log shape and the shape taken in the model.

Key words: *modeling, sawing patterns, logs, cross-section shape, longitudinal-section shape*

INTRODUCTION

The scanning of logs by means of two- and three-axis scanners and computer processing of the information are an important part of the modern methods for simulation modeling of log-sawing to lumber. An alternative for removing the unavoidable deviations in designing of sawing patterns using idealized log shape is the precise sorting by diameter (Kaliteevsky and Gudkov, 1995). This alternative is traditionally considered as cost-efficient and difficult.

Another solution is the opportunity to apply appropriate scanning-and-measurement system and mathematical models for processing the information, resulting in a model for sawing by using the actual shape and dimensions of logs.

The objective of present study was to develop an appropriate model that could operate with scanned dimensional values of positions and cross-section diameters of logs and to obtain values that could be used further for determining of the closest log shape to the actual one and the real volume.

METHOD OF STUDY

The method is based on the fact that the real shape of logs is represented precisely as a set of cross-sections taken at equal intervals along their natural axis after scanning by two-axis scanner and the possibility for their processing. The precision of establishment of the model shapes of logs depends on the dimensional values established of the positions and diameters by scanning. This is because the set of coordinates of points of the four generant lines and the approximated shapes in cross-and longitudinal sections direction are obtained by means of mathematical models, which are independent of the results of scanning. Only the positions of sections are processed by modeling (Blagoev, 2004, 2006) and their addition with the remaining parameters necessary for adjustment of the shapes. All this allows designing of maximum sawing patterns by means of approximated log shapes, which is a new way of modeling the sawing process and has substantial advantages over the current practice.

RESULTS

The application of the model for primary processing of scanning results (Blagoev, 2006) and after setting the conditions $y_i = P_{yi} - y_t$ and $x_i = P_{xi} - x_t$, where the ordinate $y_t = P_{yi}min$ and the abscissa $x_t = P_{xi}min$ are the characterizing parts of the coordinates of tangent lines, allowed to determine the coordinates of points of pairs generant lines of logs in each of the two scanned directions j = 1 along axis Oy and j = 2 along Ox, by means of arrows $f_{ji} = (P_{ji} - y_{tji})/2$, represented in Table 1. In this process we do not look for centers of cross-sections but the points coordinates of generant lines are part of the positions of the cross-sections, i.e., their determination is based on the results of scanning.

Except by point coordinates of four generant lines, log shape is characterized also by parameters like: middle of the section by direction of scanning - C_{1i} and C_{2i}; differences between diameters measured on the same section $\pm m_{(1,2)i}$; mean of the diameters measured on the same section $d_{(1,2)iav}$; differences between coordinates of points of the current and first cross-sections $\pm e_{[(ja\div b),i]}$ and respective methods for their determination are proposed. The results allow a precise determination of log volume as a sum of elementary sectors along their length according the formula:

$$q = \frac{\pi}{4}\left[d^2_{[(1.2)lav;(1,2)nav]av} + \sum_{i=2}^{n-1} d^2_{(1,2)iav} \right]\Delta L$$

The classification of logs by shapes of cross sections is done by relating them to the main groups of cross-sections. Such groups are:

1. Cross-sections with irregular rounded shape allowing to be approximated to a round shape and to be processed by batch log sawing;
2. Cross-sections with irregular rounded shape allowing to be approximated to an ellipsoid shape and to be processed by batch log sawing;
3. Cross-sections with irregular rounded shape allowing to be processed by batch log sawing;
4. Cross-sections with irregular rounded shape that are processed individually.

The logs are classified into the first group in the cases when the current differences between the perpendicular diameters $\pm m_{(1,2)i}$ are equal or smaller than the maximum allowed ones for this group. If these conditions are not met, the algorithm continues the analysis in searching for the next closest shape. When the values of $\pm m_{(1,2)i}$ are larger than allowed for the first group and the sign of differences is constant, the log is classified to the group with ellipsoidal shape.

Classification into the third group requires comparison of values both of $\pm m_{(1,2)i}$ and $\pm e_{[(ja\div b),i]}$, the latter being differences between point coordinates of the closer (or distant) generant line of the current cross-section and that at the smaller log end, and the allowed deviations for the group. The allowed deviations from regular shape in this group are larger since the shape is more irregular and in spite of processing method, the yield will be lower. The logs that cannot be classified into the third group should be processed individually. The maximum deviations are determined by optimizing the process for the different size groups.

Classification of logs according to longitudinal sections is based on the fact that the sections are characterized by the change of volume of taper zone. This zone is outlined by a rectangle determined by the diagonal points A and B on Figure 1. The ordinate of point B is expressed by the ordinate of point A and half of the difference (f) between maximum- and small-end diameters (Fig. 1). All generant lines describing the different log shapes start at point A and finish at point B.

The model proposed is based on determining of four model lines in the taper zone of each log using the two values of scanning: $0.5d_{sed}$ and $0.5d_{sed} + f$, and only the line parallel to the applicant axis is an exception from the model lines starting at point A and finishing at point B. The drawing of the other three lines is done by determining of ordinates of points in the sections by means of equations of type:

$$y_{mi} = 0.5d_{sed} + k_i f,$$

where y_{mi} is the ordinate at point i of the model line, cm;
k_i is a coefficient determining precisely the part of the maximum difference set between the ordinates for a section i.

Therefore, at a difference *f* set between ordinates, drawing of the three model lines depends on the values of coefficient k_i. These coefficients depend directly on the type of curve and their determination is done by means of empirical relationships derived by least-square method. They are a copy of the of the four model shapes of generant lines presented on Figure 1. By means of differences between ordinates of mode shapes y_{mi} and the measured ones y_i, we could calculate the standard deviations σ_i of the differences in the four possible shapes of the generant lines:

$$\sigma = \pm\sqrt{\frac{\sum_{i=1}^{n}(y_{mi} - y_i)^2}{n}},$$

where y_{mi} are the ordinates of model lines
y_i - ordinates of the measured generant lines, equal to the half of diameters in the sections measured, cm;
n - number of points analyzed.

The longitudinal section shape of the log is set to the model line where σ has the lowest value.

CONCLUSIONS

A mathematical model is proposed for processing of results of scanned logs by means of two-axis scanner and presenting of values for precise determination of log volume as a sum of volumes of smaller-length sections. The model allows determining of approximated shapes of logs in four groups, both in cross- and longitudinal section directions. The results allow modeling of log sawing by using approximated cross- and longitudinal section shapes and designing of maximum sawing patterns.

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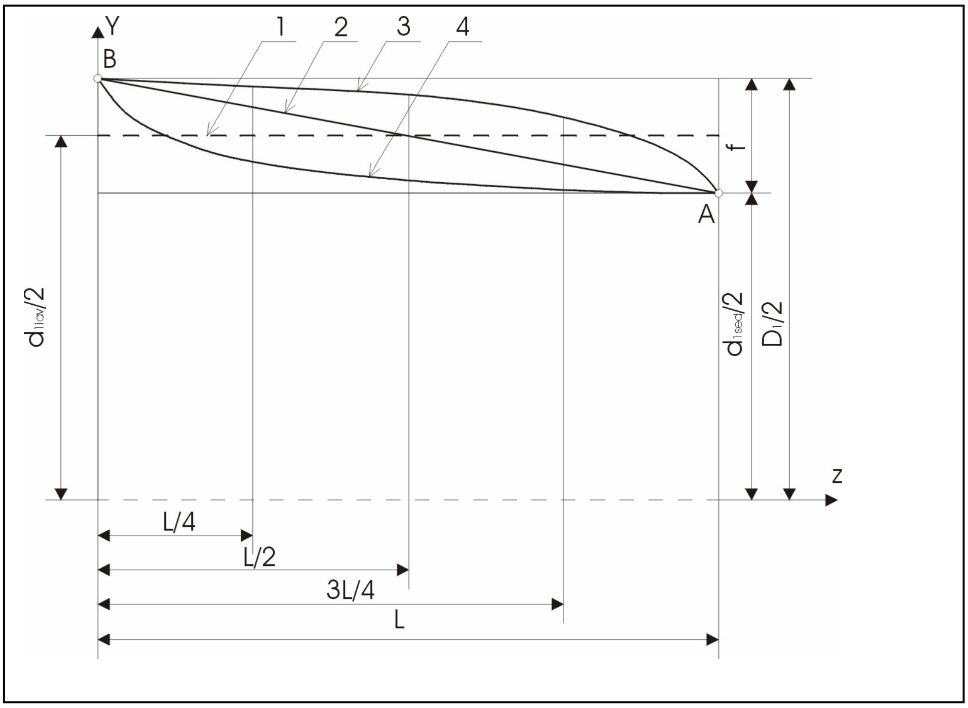
Tabe 1. A method for determining coordinates of the points of pairs of generant lines, expressing a unified approach of disposition of log sections scanned in a three-dimensional coordinate system.

Section scanned No	Scanning by direction	Measured coordinates of points of	
		closer generant line	distant generant line
		xi, yi, zi - abscissas, ordinates and applicants at i-th section scanned; j - direction of scanning; i - number of the section scanned; indices a and b represent the closer and distant generant line, respectively	
1	j = 1	$x_{1a}=x_1+0.5d_{2.1}$; $y_{1a}=y_1$; $z_1=0$	$x_{n+1b}=x_1+0.5d_{2.1}$; $y_{n+1b}=y_1+d_{1.1}$; $z_1 = 0$
	j = 2	$x_{1a}=x_1$; $y_{1a}=y_1+0.5d_{1.1}$; $z_1=0$	$x_{n+1b}=x_1+d_{2.1}$; $y_{n+1b}=y_1+0.5d_{1.1}$; $z_1 = 0$
2	j = 1	$x_{2a}=x_2+0.5d_{2.2}$; $y_{2a}=y_2$; $z_2=\Delta L$	$x_{n+2b}=x_2+0.5d_{2.2}$; $y_{n+2b}=y_2+d_{1.2}$; $z_2 = \Delta L$
	j = 2	$x_{2a}=x_2$; $y_{2a}=y_2+0.5d_{1.2}$; $z_2=\Delta L$	$x_{n+2b}=x_2+d_{2.2}$; $y_{n+2b}=y_2+0.5d_{1.2}$; $z_2 = \Delta L$
3	j = 1	$x_{3a}=x_3+0.5d_{2.3}$; $y_{3a}=y_3$; $z_3=2\Delta L$	$x_{n+3b}=x_3+0.5d_{2.3}$; $y_{n+3b}=y_3+d_{1.3}$; $z_3 =2\Delta L$
	j = 2	$x_{3a}=x_3$; $y_{3a}=y_3+0.5d_{1.3}$; $z_3=2\Delta L$	$x_{n+3b}=x_3+d_{2.3}$; $y_{n+3b}=y_3+0.5d_{1.3}$; $z_3 = 2\Delta L$
4	j = 1	$x_{4a}=x_4+0.5d_{2.4}$; $y_{4a}=y_4$; $z_4=3\Delta L$	$x_{n+4b}=x_4+0.5d_{2.4}$; $y_{n+4b}=y_4+d_{1.4}$; $z_4 =3\Delta L$
	j = 2	$x_{4a}=x_4$; $y_{4a}=y_4+0.5d_{1.4}$; $z_4=3\Delta L$	$x_{n+4b}=x_4+d_{2.4}$; $y_{n+4b}=y_4+0.5d_{1.4}$; $z_4 = 3\Delta L$
n	j = 1	$x_{na}=0.5d_{2.n}$; $y_{na}=y_n=y_t=0$; $z_n=(n-1)\Delta L$	$x_{n+nb}=0.5d_{2.n}$; $y_{n+nb}=d_{1.n}$; $z_n =(n-1) \Delta L$
	j = 2	$x_{na}=x_{.n}=x_t=0$; $y_{na}=0.5d_{1.n}$; $z_n=(n-1)\Delta L$	$x_{n+nb}=d_{2.n}$; $y_{n+nb}=0.5d_{1.n}$; $z_n =(n-1) \Delta L$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