INFLUENCE OF PROCESSING LOGS' CONICITY UPON THE OUTPUT WHEN LOG CONVERSION

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Abstract

The proposed paper presents several considerations concerning the influence of conicity on the cutting efficiency accounting the bole foe a sectioned conical form.
Other aspects such as: conicity measurement, conditions under which conicity is admissible, are also presented together with two important problems:
- *how to obtain a prism with a maximal cross-section included in a circle that represents the thin end of the bole*
- *how to obtain sawn timber of maximal section included in circular areas which remain as externalities after the cutting of the prism.*

It should be reminder that the total efficiency in sawn timber processing, several other factors play an important role, such as: the type of cutting and processing machinery, cutting procedures, boles form etc.

Key words: *conicity, cutting efficiency, conversion log, cutting model*

INTRODUCTION

Generally, the conicity of the stem is given by the decrease of the diameter from the base towards the top. It is a form defect. For the round wood, the anomalous conicity represents a continuous and anomalous decrease of the diameter from the thick end to the thin one.

Generally, the contour curve of the tree bole can be considered more or less close to the generatrix curve (line that through rotation generates a rotation body) of some rotation geometric bodies: cylinder, cone, apolonic paraboloid, neiloid etc (fig. 1).

General equation of the curves generating fundamental dendrometric types is (Giurgiu, 1968,1972,1997; Leahu, 1994):

$$\mathbf{y^2 = p\, x^{2r}},$$

where: y represents the radius of any cross section

x – distance of respective section with respect to the apex of the curve

p – parameter that determines the size ratio between x and y

r – grade of the curve form. It can take different values, such as:

- for cylinder: $r = 0 \Rightarrow y^2 = p$

- for apolonic paraboloid: $r = 1/2 \Rightarrow y^2 = p\,x$
- for cone: $r = 1 \Rightarrow y^2 = px^2$
- for neiloid: $r = 3/2 \Rightarrow y^2 = p\,x^3$

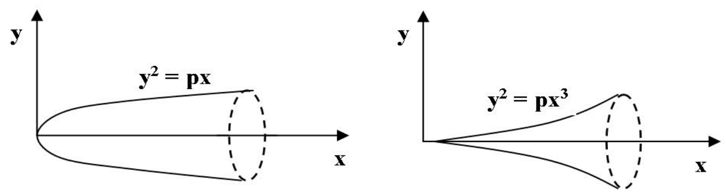


Fig. 1 Generatrix curve for rotation geometric bodies (apolonic paraboloid and neiloid)

The form of the tree bole varies from one species to another and even from one tree to another, according to age, consistency, site quality, etc. However, some certain typical characteristics of the tree form are highlighted, the bole form of the longitudinal section being divided as it follows (see fig. 2):

1. the base of the bole, characterized through a concave form and located at the basis (this form defect is called stretching);
2. the middle part of the bole, convex form;
3. superior part of the bole, convex form.

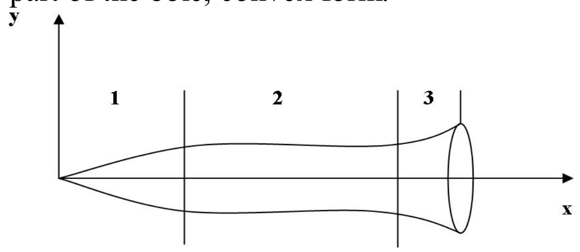


Fig. 2 Contour curve of a tree bole

In the inferior part of the bole, the form is very stretched, then it continues to be convex till a point of inflexion placed between 0.1 and 0.2 of the height, and in the upper part it becomes concave. The curvature is relatively pronounced under the canopy.

The tree bole can be alike with some geometric forms on some segments.

The trees that grew isolated, on the forest margin or in stands that were very thickened, have an approximately cone-like form, due to the additional mechanical stress.

The conicity is also more pronounced in resinous trees than in deciduous ones. The fast-growing species with a poor wood density have also a greater conicity.

Generally, conicity (Co) is measured by the difference between the diameter at the thick end (D) and that of the thin end (d), in cm, with respect to the whole length of the piece, in m.

If the percent expression is needed, then the length will also be expressed in cm, and the ratio is multiplied with 100.

$$Co = \frac{D-d}{L} x100,\% \qquad (1)$$

The conicity is usually taken into account only on the area without stretching (see fig. 3).

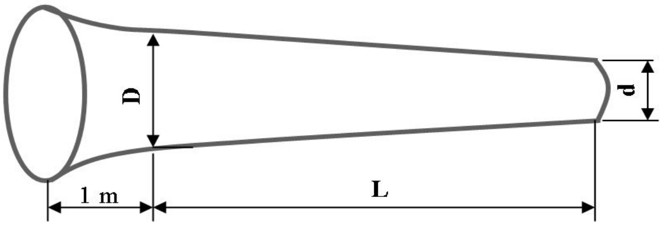


Fig. 3 Conicity measurement

The limit from which conicity is considered anomalous is foreseen in the standards. In general, the conicity is considered anomalous when the diameter of log (tree) degreases with more then 1 cm per 1 linear meter length.

According to RS (Romanian Standards) for the resinous round wood, beech, durmast, oak, Hungarian oak şi Turkey oak, different softwood and hardwood deciduous trees for the industrialization, the anomalous conicity is given below:

Table 1 The anomalous conicity for round wood according to RS

Defect name		Quality class			
		Resonance	*Aesthetic veneer*	*Technique veneer*	*Timber*
Anomalous conicity, %, max.	- for the resinous RS 1294:1993	Not admitted	1	1	Any value
	- for beech RS 2024:1993	-	1,5	1,5	Any value
	- for oaks RS 1039:1993	-	2		Any value
	- for different softwood and hardwood deciduous trees, RS 3302:1993	-	1,5	1,5	Any value

MATERIAL AND METHOD

As it can be noticed in the above tables, the anomalous conicity is admitted for all the logs for timber processing (class C), regardless their species. But the anomalous conicity of class C logs and those of class Ft (technique veneer) have as a result the diminution of the output in timber and veneer.

The present paper presents some aspects regarding the conicity influence (expressed in %) upon the output when log conversion, when we assume that the log has a frustum form.

As regards the *qualitative output* through the log conversion with anomalous conicity, poorly-quality products are achieved, that present inclined fiber.

The influence of conicity upon the *quantitative output* when log conversion into timber, in the case of maximum model usage, are shown by using mathematical relations proved in the specialized literature (Ciubotaru, 1997).

Two more important issues are of concern when converting the cylindrical area, that is:

- achievement of a prism with maximum cross section, inscribed in the circle of the thin end of the log;
- achievement of some boards of maximum sections inscribed in the circle segments that exceeded the prism sides.

a. Maximum section prism

There is one log with known length L (fig.4). The diameter at the thick end is noted with D, and that at the thin end with d. All the three characteristics are expressed in cm, and the conicity is expressed in percents.

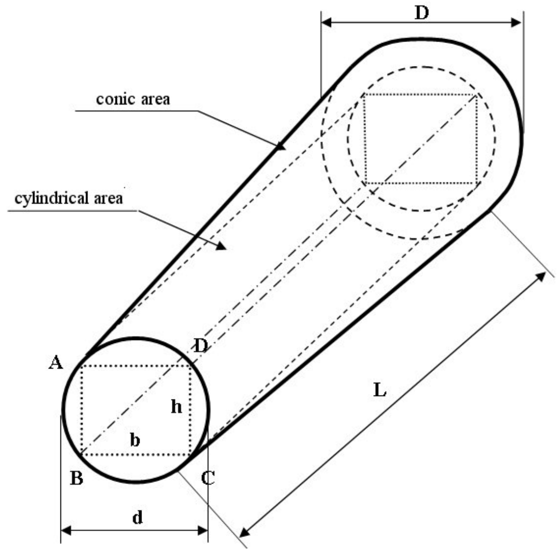


Fig. 4 Calculation scheme of the maximum prism's height

For resinous trees, maximal conversion models are used, resulting maximum quantitative outputs. In the case of slab conversion, the volume of the prism will be maximum when the area of ABCD rectangle, inscribed within the circle with diameter d, is maximum that is when ABCD is square.

$$h = b = 0{,}707 \text{ x } d \Rightarrow d = 1{,}4 \text{ x } h \quad (2)$$

In this situation the volume of the prism that can result from the log with length L is:

$$V_{pr} = L \text{ x } b \text{ x } h = L \text{ x } d^2 / 2 \quad (3)$$

Thus, the quantitative output in the prisms is:

$$R = \frac{V_{pr}}{V_b} \text{x}100 = \frac{6 \cdot d^2}{\pi \cdot (D^2 + d^2 + dD)} \text{x}100\text{, \%} \quad (4)$$

where V_{pr} represents the volume of the prism with a square base.

b. conversion of the segments exceeding the prism sides

Conversion of the hachured areas is needed for a rational usage of the cylindrical area of the conversion logs. This cylindrical area represents about 80% of the real volume of the conversion log (more exactly 1.57x R), which usually has a frustum–like form.

The issue of rational conversion of these segments involves the determination of the size of the maximum area rectangles inscribed in these area, issue solved by Prof. H.L. Feldman in his research "System of maximum cutting models". Thus, the following results were obtained (fig.5):

$$s = 0{,}1 \cdot d\text{, (5)}$$

$$b = 0{,}43 \cdot d\text{, (6)}$$

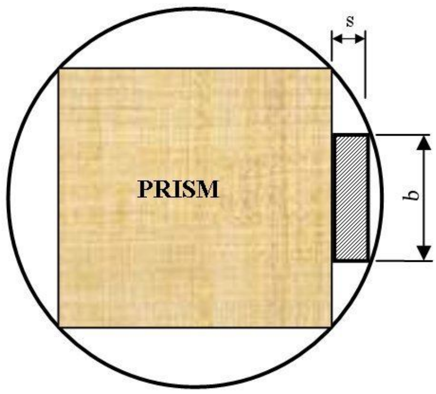
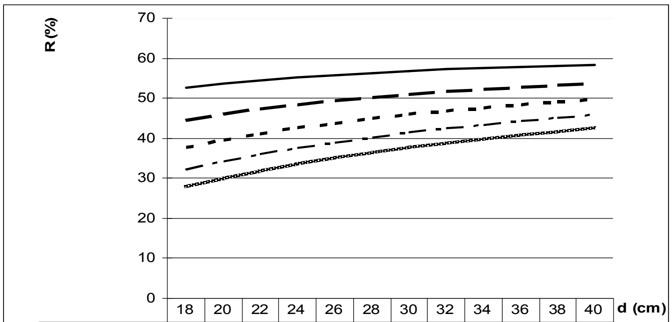


Fig. 5 Conversion of segments exceeding the prism sides (square); view upon the thin end of the log

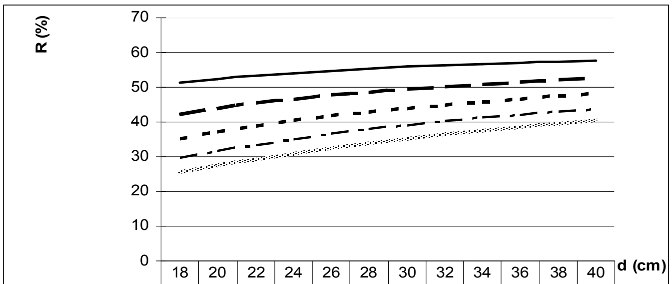
RESULTS AND DISCUSSIONS

By using the formulas 3 and 4, the variation of the quantitative output was determined graphically according to the conicity and length of the log (fig. 6, 7).



	18	20	22	24	26	28	30	32	34	36	38	40
Co = 1%	52.7	53.7	54.5	55.2	55.8	56.3	56.7	57.1	57.5	57.8	58.1	58.4
Co = 2%	44.2	45.7	47.0	48.2	49.2	50.0	50.8	51.5	52.1	52.7	53.2	53.7
Co = 3%	37.5	39.3	40.9	42.4	43.6	44.7	45.7	46.6	47.4	48.2	48.9	49.5
Co = 4%	32.1	34.1	35.9	37.5	38.9	40.2	41.3	42.4	43.3	44.2	45.0	45.7
Co = 5%	27.8	29.8	31.7	33.3	34.9	36.2	37.5	38.6	39.7	40.6	41.5	42.4

Fig.6 Variation of quantitative output when slab conversion of the logs with a conicity of 1-5% and with a length of L = 3.5 m



	18	20	22	24	26	28	30	32	34	36	38	40
Co = 1%	51.4	52.5	53.4	54.1	54.8	55.4	55.9	56.3	56.7	57.1	57.4	57.7
Co = 2%	42.2	43.8	45.2	46.5	47.5	48.5	49.3	50.1	50.8	51.4	52.0	52.5
Co = 3%	35.1	37.0	38.7	40.2	41.5	42.7	43.8	44.8	45.7	46.5	47.2	47.9
Co = 4%	29.6	31.6	33.4	35.1	36.6	37.9	39.1	40.2	41.2	42.2	43.0	43.8
Co = 5%	25.2	27.3	29.1	30.8	32.4	33.8	35.1	36.3	37.4	38.4	39.3	40.2

Fig.7 Variation of quantitative output when slab conversion of the logs with a conicity of 1-5% and a length of L = 4 m

It is noticed that the *quantitative output* increases altogether with the increase of the diameter, but decreases with *the increase of conicity*.

For the logs with long lengths (L > 5m), it is recommended as a section to be made before conversion. Although conicity remains the same, the output increases because a prism with a greater base will result from a greater volume piece (that from the thick end), thus with a greater volume.

In practice, to determine the base of the prism, when the log diameter and converted piece width are known, some tables, diagrams etc were made that take into account the super-dimensions for drying shrinkage.

In the case b, conversion of the segments exceeding the prism sides, according to fig. 5, formulas 5 and 6, the four pieces had the volume:

$V_{dr} = 4 \cdot s \cdot b \cdot L = 0,172 \cdot d^2 \cdot L$ (7)

In this case the quantitative output becomes:

$$R(\%) = \frac{V_{pr} + V_{dr}}{V_b} x100 =$$

$$= 806{,}4 \cdot \frac{d^2}{\pi \cdot (d^2 + D^2 + d \cdot D)}, (8)$$

Comparing the two outputs, it results that if the four lateral areas of the prism are capitalized at maximum through the model in fig. 5, a quantitative gain of 25.6% is achieved with respect to the first situation.

By exemplifying, for a log of 4m long, with a conicity of 1%, the outputs in fig. 8 are achieved:

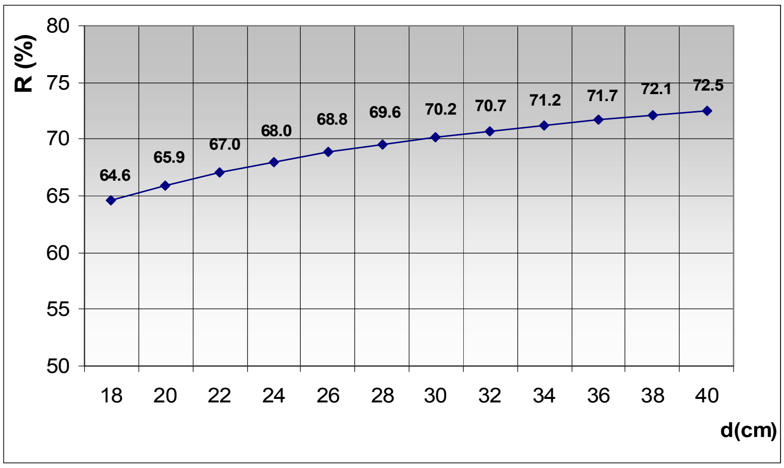


Fig.8 Quantitative output when converting a log with L=4 m, Co=1%

CONCLUSIONS

The calculated outputs are achieved when from the central area a maximum volume prism is needed, and four pieces (boards) on the sides, but all of them having the length equal with the length of the log. These outputs are pretty low, because only the central area (cylinder) is capitalized. To capitalize at maximum the raw material and to achieve maximum outputs, boards should be achieved from the remaining areas. But a higher conicity and the thickness of the needed piece is greater, the shorter the length of these boards in comparison with that of the log.

Thus, when pronounced-conicity log conversion, a number of lateral boards come from the conic area and their lengths will be shorter than the length of the log. These boards are cut shorter, so that some pieces of lengths and widths, that are standard or on beneficiary request, to be achieved, and their volume to be as great as possible.

In the discussed aspects, the super-dimensionings for the drying conversion haven't been taken into account, only those from maximum model standpoint. In practice, the calculus of the maximum prism' height and width is corrected due to the reduction of the size number that are needed to be accomplished in the timber production, and in accordance with the log sorting criteria.

For simplification, it was also insisted on the procedure of slab sawing (used especially in resinous trees). For the deciduous conversion into timber, qualitative conversion models are predominantly used that have in view the achievement of some maximum qualitative output.

It shouldn't be forgotten that upon the total output in timber some other factors interferes, such as: way of storing logs in the warehouse, type of conversion and processing equipment, conversion procedures, way of production organization.

The assessed aspects don't take into account the dimensional and qualitative specification of timber, the fact that sometimes the log cross section is elliptical and non-circular, and the presence of other form defects (e.g. curvature).

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