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ANALYSIS OF DIAMETERS AND TAPER OF DIAMETER OF BEECH LOGS IN I/III CLASS OF QUALITY

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ABSTRACT

This paper presents the results of investigations of diameter and taper of diameter of beech logs. The investigation was performed on raw material with dimensions: 3,0 m; 4,0 m; and 5,0 m in length and assigned in I –st; II – nd; III – rd class of quality. A total number of 90 logs were investigated i.e. 30 for each length. For logs of 3,0 m in length, mean diameter was 48,3 ± 2,38 cm, 1,6 ± 0,14 cm/m taper of diameter and belonging to „D” group of thickness. For logs of 4,0 m in length, mean diameter was 45,6 ± 1,48 cm, 1,4 ± 0,13 cm/m taper of diameter belonging to „C” group of thickness. For logs of 5,0 m in length, mean diameter was 44,8 ± 1,5 cm and 1,4 ± 0,14 cm/m taper of diameter belonging to „C” group of thickness.

Key words: beech logs, diameter, taper, group of thickness.

1. INTRODUCTION

This paper is an attempt, at practical operating conditions of the saw mill plant in the “Ilinopromet” company from Kavadarci in the Republic of Macedonia, to assess the diameters and taper of diameter of beech logs using data related to the experimental measurements of the diameters of thick and thin end of the log.

Why are such analyses needed?

Analyses of such a character in practice should be constantly carried out in the log stack of the sawmill industry.

The procedure for defining the log taper is connected with establishing both class of quality and participation of the additional zone in relation to the max. quantitative yield of logs and increment in production of sawed timber.

2. METHODS OF WORK

Beech logs originated from Kozuv Mountains and the investigation was carried out in the wood working company “ Ilinopromet” – Kavadarci, the Republic of Macedonia.

During the investigations the following activities were carried out:
- selection of logs and measuring their parameters, and
- application of statistical methods for data processing.

The selection of logs was made based on the current state of storage for logs. This means that the analysis covered logs used in the ordinary operation of the company.

Wood species was beech, which dominated as material for saw mill processing. The analysis covered logs of I, II and III quality class, with 3.0; 4,0 and 5,0 m. length.

Calculation of the mean diameter was carried out by crosswise measuring of the thick and thin end of each log, separately. The length of logs was measured with measuring tape.

The mean diameter was calculated with the formula:

$$d_{sr} = \frac{d_1 - d_2}{2} \quad \text{(cm)}$$

Where:

d_{sr} - mean diameter of the log (cm)

d_1 - diameter of the thin end of the log (cm)

d_2 - diameter of the thick end of the stump (cm)

The log taper was calculated with the formula:

$$S = \frac{d_1 - d_2}{l} \quad \text{(cm/m)}$$

S - log taper (cm/m)

d_1 - diameter of the thin end of the log (cm)

d_2 - diameter of the thick end of the stump (cm)

l - length of the log (cm)

Table 1 was used to estimate the group of log thickness according to values of the log taper.

Table 1. *Group of thickness of the logs according to Mihajlov*

Group of log thickness	Log taper S (cm/m)
A	up to 0,5
B	0,5 – 1,0
C	1,1 – 1,5
D	1,51 – 2,0
E	over 2,0

For calculating the volume of timber the formula used was:

$$V = \frac{d_{sr^2} \bullet \pi}{4} \bullet l \quad (\text{m}^3)$$

V - volume of the log (m^3)

d_{sr} - mean diameter of the log (cm)

l - length of the log (cm)

$\pi = 3,14$

The data obtained was processed by mathematical – variation statistical methods and the following parameter were determined: mean of the statistical sum, mean error, standard deviation, standard deviation error, coefficient of variation and coefficient of variation error.

3. INVESTIGATION RESULTS

The results of the research concerning the number of sawn logs, their dimensions, class of quality, volume and log taper are presented in tables 2, 3 and 4.

Based on the data shown in table 2, it can be concluded that a total of 30 logs was analyzed, assigned in I/III class of quality with 3,0 in length.

Diameter of the thin and thick end of the log varied from 27,0 to 68,0 cm and from 29,0 to 76,0 cm respectively. Mean diameter for all investigated logs varied from 28,0 to 74,0 cm.

The log taper is shown in column 6 and it ranges from 0,67 to 267 cm/m, being directly dependent on the diameter of the thin and thick end of the logs. If the logs have a greater cylindrical shape, the log taper is smaller, and vice versa. The volume of the logs varies from 0,185 m^3 to 1,255 m^3 and it is increasing with increment in the diameter at a constant length.

Table 2. *Data regarding beech logs,3,0 m in length*

Ord. No.	**Diameter of thin end**	**Diameter of thick end**	**Mean diameter**	**Length**	**Log taper**	**Volume**	**Quality class**
	d1 (cm)	d2 (cm)	dsr (cm)	l (cm)	S (cm/m)	Vo (m^3)	K
1	2	3	4	5	6	7	8
1	38,0	47	42,0	3,0	3,00	0,415	I/III
2	41,0	44,0	42,0	3,0	1,00	0,415	
3	35,0	38,0	36,0	3,0	1,00	0,305	
4	34,0	36,0	35,0	3,0	0,67	0,288	
5	70,0	72,0	71,0	3,0	0,67	1,187	
6	72,0	76,0	74,0	3,0	1,33	1,290	
7	28,0	30,0	29,0	3,0	0,67	0,198	
8	27,0	29,0	28,0	3,0	0,67	0,185	
9	36,0	38,0	37,0	3,0	0,67	0,322	
10	37,0	39,0	38,0	3,0	0,67	0,340	
11	36,0	39,0	37,0	3,0	1,00	0,322	
12	42,0	44,0	43,0	3,0	0,67	0,435	
13	44,0	50,0	47,0	3,0	2,00	0,520	
14	54,0	60,0	57,0	3,0	2,00	0,765	
15	48,0	52,0	50,0	3,0	1,33	0,589	
16	52,0	58,0	55,0	3,0	2,00	0,712	
17	60,0	65,0	62,0	3,0	1,67	0,905	
18	68,0	72,0	70,0	3,0	1,33	1,154	
19	41,0	49,0	45,0	3,0	2,67	0,477	
20	42,0	48,0	45,0	3,0	2,00	0,477	
21	36,0	42,0	39,0	3,0	2,00	0,358	
22	38,0	44,0	41,0	3,0	2,00	0,396	
23	62,0	70,0	66,0	3,0	2,67	1,026	
24	72,0	74,0	73,0	3,0	0,67	1,255	
25	48,0	55,0	51,0	3,0	2,33	0,612	
26	38,0	46,0	42,0	3,0	2,67	0,415	
27	32,0	38,0	35,0	3,0	2,00	0,288	
28	49,0	55,0	52,0	3,0	2,00	0,637	
29	52,0	60,0	56,0	3,0	2,67	0,738	
30	48,0	54,0	51,0	3,0	2,00	0,612	
31	**TOTAL**					**17,684 m^3**	

Table 3 shows data for beech logs with a length of 4,0 m. Column 2 from the same table shows the diameters of the logs of the thin end. It can be concluded that these diameters range from 28,0 to 56,0 cm. Column 3 of the table shows the data related to the diameters of thick end of log. It can be noticed that they are within the range of 30,0 to 60,0 cm. Mean diameter of the logs varies from 29,0 to 58,0 cm. Log taper is within the range of 0.25 to 3,0 cm/m. Depending on the diameters of the logs, their volume varies from 0.264 to 1,056 m^3 and accordingly assigned in I/III class of quality.

Table 3. *Data regarding beech logs,4,0 m in length*

Ord. No.	**Diameter of thin end**	**Diameter of thick end**	**Mean diameter**	**Length**	**Log taper**	**Volume**	**Quality class**
	d1 (cm)	d2 (cm)	dsr (cm)	l (cm)	S (cm/m)	Vo (m^3)	K
1	2	3	4	5	6	7	8
1	31,0	36,0	33,0	4,0	1,25	0,342	I/III
2	31,0	35,0	33,0	4,0	1,00	0,342	
3	47,0	52,0	49,0	4,0	1,25	0,754	
4	50,0	53,0	51,0	4,0	0,75	0,817	
5	34,0	46,0	40,0	4,0	3,00	0,502	
6	28,0	30,0	29,0	4,0	0,50	0,264	
7	50,0	55,0	52,0	4,0	1,25	0,850	
8	54,0	53,0	53,0	4,0	0,25	0,882	
9	53,0	56,0	54,0	4,0	0,75	0,916	
10	53,0	60,0	58,0	4,0	1,75	1,056	
11	56,0	60,0	58,0	4,0	1,00	1,056	
12	46,0	48,0	47,0	4,0	0,25	0,694	
13	47,0	46,0	46,0	4,0	0,25	0,664	
14	33,0	38,0	35,0	4,0	1,25	0,385	
15	50,0	56,0	53,0	4,0	1,50	0,882	
16	48,0	59,0	53,0	4,0	2,75	0,882	
17	44,0	48,0	46,0	4,0	1,00	0,664	
18	50,0	54,0	52,0	4,0	1,00	0,850	
19	38,0	44,0	41,0	4,0	1,50	0,528	
20	35,0	45,0	40,0	4,0	2,50	0,502	
21	48,0	58,0	53,0	4,0	2,50	0,882	
22	35,0	45,0	40,0	4,0	2,50	0,502	
23	52,0	58,0	55,0	4,0	1,50	0,950	
24	34,0	42,0	38,0	4,0	2,00	0,453	
25	40,0	46,0	43,0	4,0	1,50	0,580	
26	36,0	42,0	39,0	4,0	1,50	0,477	
27	50,0	54,0	52,0	4,0	1,00	0,850	
28	38,0	46,0	42,0	4,0	2,00	0,554	
29	32,0	40,0	35,0	4,0	2,00	0,385	
30	44,0	50,0	47,0	4,0	1,50	0,694	
31	**TOTAL**					**21,541 m^3**	

Table 4 presents data from investigations concerning diameter of the thin and the thick end, the mean diameter, taper, volume and class of quality of logs with a length of 5,0 m.

It can be concluded that the logs are I / III class quality with total number of 30. The diameter of the thin end of logs covered by this analysis ranged from 28,0 to 54,0 cm.

Column 3 of Table 3 presents data on diameter of the log at a constant length of 5,0 m, which ranges from 30,0 to 68,0 cm. Mean diameter varies from 31,0 to 60,0 cm.

The log taper is within range of 0,4 to 3,2 cm/m, whereas timber volume varies between 0,377 m^3 and 1,143 m^3.

Table 4. *Data regarding beech logs, 5,0 m in length*

Ord. No.	**Diameter of thin end**	**Diameter of thick end**	**Mean diameter**	**Length**	**Log taper**	**Volume**	**Quality class**
	d1 (cm)	d2 (cm)	dsr (cm)	l (cm)	S (cm/m)	Vo (m^3)	K
1	2	3	4	5	6	7	8
1	30,0	32,0	31,0	5,0	0,4	0,377	I/III
2	28,0	35,0	31,0	5,0	1,4	0,377	
3	54,0	56,0	55,0	5,0	0,4	1,187	
4	43,0	49,0	46,0	5,0	1,2	0,830	
5	52,0	68,0	60,0	5,0	3,2	1,413	
6	43,0	45,0	44,0	5,0	0,4	0,608	
7	46,0	50,0	48,0	5,0	0,8	0,904	
8	46,0	52,0	49,0	5,0	1,2	0,942	
9	32,0	38,0	35,0	5,0	0,8	0,481	
10	44,0	50,0	47,0	5,0	1,2	0,867	
11	54,0	58,0	56,0	5,0	0,8	1,231	
12	42,0	46,0	44,0	5,0	0,8	0,608	
13	44,0	54,0	49,0	5,0	2,0	0,942	
14	53,0	56,0	54,0	5,0	0,6	1,144	
15	38,0	46,0	41,0	5,0	1,4	0,660	
16	38,0	44,0	41,0	5,0	1,2	0,660	
17	34,0	38,0	36,0	5,0	0,8	0,509	
18	43,0	47,0	45,0	5,0	0,8	0,795	
19	33,0	41,0	37,0	5,0	1,4	0,537	
20	52,0	68,0	60,0	5,0	3,2	1,413	
21	50,0	66,0	58,0	5,0	3,2	1,320	
22	47,0	53,0	50,0	5,0	1,2	0,981	
23	40,0	46,0	48,0	5,0	1,2	0,904	
24	40,0	44,0	44,0	5,0	0,8	0,608	
25	29,0	37,0	33,0	5,0	1,6	0,427	
26	37,0	45,0	41,0	5,0	1,6	0,660	
27	40,0	50,0	45,0	5,0	2,0	0,795	
28	31,0	37,0	34,0	5,0	1,2	0,454	
29	35,0	47,0	41,0	5,0	2,4	0,660	
30	38,0	46,0	42,0	5,0	1,6	0,692	
31	**TOTAL**					**25,680 m^3**	

3.1 Beech logs 3,0 m in length

Data shown in Table 2 was used to estimate the statistical values of the diameter of the thin and thick end of the log, mean diameter of the log and taper of the log with length of 3,0 m. (Table 5).

Table 5. *Statistical data regarding diameter and log of the taper / beech 3,0 m in length*

	Mean value	Standard deviation	Coefficient of variation
	Xsr ± fxsr	S ± fs	V ± fv
Diameter of thin end d_1 (cm)	46,0 ± 2,355	12,900 ± 1,666	28,044 ± 3,895
Diameter of thick end d_2 (cm)	50,8 ± 2,415	13,226 ± 1,708	26,035 ± 3,582
Mean diameter d_{sr} (cm)	48,3 ± 2,381	13,039 ± 1,684	26,995 ± 3,731
Log taper S (cm/m)	1,6 ± 0,139	0,760 ± 0,098	47,449 ± 7,378

It can be noticed from Table 5, that the diameter of the thin end is 46,0 ± 2,355, with standard deviation of 12,9 ± 1,67 and coefficient of variation of 28,0 ± 3,9 % . Mean diameter of the thick end is 50,0 ± 2,4 cm, with standard deviation 13,2 ± 1,7 and coefficient of variation of 26,0 ± 2,6 %.

Mean diameter of the logs is 48,0 cm ± 2,3 cm, with standard deviation of 13,0 ± 1,7 and coefficient of variation of 27,0 ± 3,7 %. Taper of the log with I/III class of quality is 1,6 ± 0,14 cm/m, standard deviation 0,76 ± 0,09 and coefficient of variation of 47,4 ± 7,3 %.

3.2 Beech logs 4,0 m in length

The results of the research for logs 4, 0 m (table 3) were statistically analyzed and they are presented in table 6.

Table 6. *Statistical data regarding diameter and log of the taper / beech 4,0 m in length*

	Mean value	Standard deviation	Coefficient of variation
	Xsr ± fxsr	S ± fs	V ± fv
Diameter of thin end d_1 (cm)	42,9 ± 1,532	8,389 ± 1,083	19,554 ± 2,619
Diameter of thick end d_2 (cm)	48,5 ± 1,456	7,973 ± 1,029	16,439 ± 2,179
Mean diameter d_{sr} (cm)	45,6 ± 1,481	8,110 ± 1,047	17,798 ± 2,370
Log taper S (cm/m)	1,4 ± 0,135	0,737 ± 0,095	51,747 ± 8,279

From the table it can be concluded that the mean value of the thin end for the wood of Beech is 42,9 ± 1,5 cm, with standard deviation of 8,4 ± 1,08 and coefficient of variation of 19,5 ± 2,6 %. The mean value of the thick end is 48,5 ± 1,4 cm, the standard deviation is 7,9 ± 1,0 and the coefficient of variation is 16,4 ± 2,1 %. Further, the mean diameter of the logs has values of 45,6 ± 1,5 cm/m, the standard deviation is 8,1 ± 1,0, and the coefficient of variation is 17,8 ± 2,3 %. The log taper has mean value of 1,4 ± 0,13, with standard deviation of 0,74 ± 0,1 and coefficient of variation of 51,7 ± 8,3 %.

3.2 Beech logs 5,0 m in length

The results of the diameter of thin and thick end, mean diameter, as well as taper of beech logs with 5,0 in length, are presented in Table 7.

Table 7 *Statistical data regarding diameter and log of the taper / beech 5,0 m in length*

	Mean value	Standard deviation	Coefficient of variation
	Xsr ± fxsr	S ± fs	V ± fv
Diameter of thin end d_1 (cm)	41,2 ± 1,411	7,725 ± 0,997	18,751 ± 2,505
Diameter of thick end d_2 (cm)	48,1 ±1,670	9,145 ± 1,181	19,000 ± 2,540
Middle diameter d_{sr} (cm)	44,8 ± 1,508	8,259 ± 1,066	18,422 ± 2,458
Log taper S (cm/m)	1,4 ± 0,144	0,787 ± 0,102	57,852 ± 9,651

Statistical results reveal that the mean value of thin end is 41,4 ± 1,4 cm, standard deviation is 9,1 ± 1,1 and coefficient of variation is 19,0 ± 2,5%. Concerning the mean diameter of the logs, one can conclude that for a total of 30 logs the value is almost 45,0 cm., with standard deviation of 8,2 ± 1,1 and coefficient of variation of 18,4 ± 2,4 %.

3.3 Comparison of the results for beech logs 3,0, 4,0 and 5,0 m in length

In order to get comparison of the results obtained, they are shown in Table 8.

Table 8. *Statistical data regarding diameter and log of the taper / beech 3,0, 4,0 and 5,0 m in length*

Wood species	Quality class	Length	Diameter of thin end d_1 (cm)	Diameter of thick end d_2 (cm)	Mean diameter	Log taper
		1	d_1 (cm)	d_2 (cm)	d_{sr} (cm)	S (cm/m)
1	2	3	4	5	6	7
Beech	I/III	3,0	46,0	51,0	48,0	1,6
		4,0	43,0	48,0	46,0	1,4
		5,0	41,0	48,0	45,0	1,4

From Table 8 we can see that that diameter of the thin end of logs varies from 41,0 cm for 5,0 m length to 46,0 cm for 3,0 m length. Also, the same conclusion can be drawn from the data concerning the diameter of the thick end of the log, where it varies from 48,0 cm to 51,0 cm for lengths of 5,0 m and 3,0 m respectively. There is no big difference among the values of mean diameter with logs of all three lengths. The values range between 45,0- to 48,0 cm.

Taper of log for 4,0 and 5,0 m in length has identical value of 1,4 cm/m and higher value of 1,6 cm/m for 3,0 in length.

Many authors have done researches of diameters and taper of beech logs.

Arsovski (1978) gives values of mean diameter within the limits of 37,7 to 44,2 cm (mean 42,3 cm) for beech logs 3,0; 4,0 and 5,0 m in length, I/III class of quality. The same author came to a conclusion that logs 4,0 in length were more common, than those of 3,0 and 5,0.

Doncev and Vasilev (1977) give values of mean diameter within the limits of 20,0 to 70,0 cm (mean 43,15)) for beech logs 2,0, 3,0, 4,0 and 5,0 m in length, III class of quality.

Rabadziski (1991) analyzed a total number of 172 beech logs with length of 4,0 m and I/III class of quality. Due to specific research conditions, the author classified 6 groups of log thickness and established min. and max. diameter of 26,0 cm and 55,0 cm. The mean diameter was 39,0 cm.

4. CONCLUSION

1. The raw materials were the sawmill logs of 3,0, 4,0, and 5,0 m length.
2. Concerning the class of quality, there were I, II and III class of quality.
3. A total of 30 logs were analyzed for each length.
4. The diameter of the thin and thick end of 3,0 m logs varied from 27,0 to 68,0 cm and 28,0 to 74,0 cm respectively. The mean diameter (statistically calculated value) was 48,3 ± 2,38 cm. The log taper was 1,6 ± 0,14 cm/m and belongs to the „D" group of thickness (Table 1).
5. The diameter of the thin and thick end of 4,0 m logs varied from 28,0 to 56,0 cm and 30,0 to 60,0 cm respectively. The mean diameter (statistically calculated value) was 45,6 ± 1,48 cm. The log taper was 1,4 ± 0,14 cm/m and belongs to the „C" group of thickness (Table 1).
6. The diameter of the thin and thick end of 5,0 m logs varied from 28,0 to 54,0 cm and 30,0 to 68,0 cm respectively. The mean diameter (statistically calculated value) was 44,8 ± 1,50 cm. The log taper was 1,4 ± 0,14 cm/m and belongs to the „C" group of thickness (Table 1).
7. The total volume of the log with 3,0 m; 4,0 and 5,0 m in length was 64,91 m^3, 17,684 m^3 and 25,68 m^3 respectively.
8. In order to get max. quantitative yield of logs at sawmill plants, similar analysis concerning evaluation of the additional zone of the row material should be carried out.

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