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**ANALYSIS OF DIAMETERS AND TAPER OF DIAMETER
OF PINE 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 pine logs. The investigation was performed on raw material with dimensions: 5,0 m and 6,0 m in length and assigned in I –st; II – nd; III – rd class of quality. A total number of 60 logs were investigated i.e. 30 for each length. For logs of 5,0 m in length, mean diameter was $42,2 \pm 1,427$ cm, $1,1 \pm 0,091$ cm/m taper of diameter and belonging to „C” group of thickness. For logs of 6,0 m in length, mean diameter was $38,9 \pm 1,240$ cm, $1,1 \pm 0,093$ cm/m taper of diameter belonging to „C” group of thickness.

Key words: pine 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 pine 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 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

Pine 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 pine, which dominated as material for saw mill processing. The analysis covered logs of I, II and III quality class, with 5,0 and 6,0 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:

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

V - volume of the log (m³)

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 parameters 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 and 3.

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 5,0 in length.

The diameter of the thin and thick end of the log varied from 28,0 to 53,0 cm and from 30,0 to 63,0 cm respectively. The mean diameter for all investigated logs varied from 29,0 to 58,0 cm.

The log taper is shown in column 6 and it ranges from 0,4 to 2,2 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 0,330 m³ to 1,320 m³ and it is increasing with increment in the diameter at a constant length.

Table 2. Data regarding pine 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	53,0	59,0	51,0	5,0	1,20	1,021	I/III
2	28,0	30,0	29,0	5,0	0,40	0,330	
3	32,0	34,0	33,0	5,0	0,40	0,454	
4	36,0	38,0	37,0	5,0	0,40	0,537	
5	48,0	59,0	53,0	5,0	2,20	1,102	
6	46,0	52,0	49,0	5,0	1,20	0,942	
7	50,0	54,0	52,0	5,0	0,80	1,144	
8	31,0	38,0	34,0	5,0	1,40	0,454	
9	50,0	56,0	53,0	5,0	1,20	1,102	
10	53,0	63,0	58,0	5,0	2,00	1,320	
11	34,0	36,0	35,0	5,0	0,40	0,481	
12	34,0	39,0	36,0	5,0	1,00	0,509	
13	42,0	48,0	45,0	5,0	1,20	0,795	
14	38,0	46,0	42,0	5,0	1,60	0,692	
15	50,0	56,0	53,0	5,0	1,20	1,102	
16	52,0	56,0	54,0	5,0	0,80	1,144	
17	48,0	56,0	50,0	5,0	1,20	0,981	
18	32,0	42,0	37,0	5,0	2,00	0,537	
19	42,0	46,0	44,0	5,0	0,80	0,608	
20	40,0	49,0	49,0	5,0	1,80	0,942	
21	33,0	40,0	36,0	5,0	1,40	0,509	
22	35,0	42,0	36,0	5,0	1,40	0,509	
23	52,0	57,0	54,0	5,0	1,00	1,144	
24	36,0	44,0	40,0	5,0	1,60	0,628	
25	42,0	46,0	44,0	5,0	0,80	0,608	
26	50,0	55,0	52,0	5,0	1,00	1,061	
27	50,0	54,0	52,0	5,0	0,80	1,061	
28	38,0	42,0	40,0	5,0	0,80	0,628	
29	44,0	46,0	45,0	5,0	0,40	0,795	
30	48,0	54,0	51,0	5,0	1,20	1,021	
31	TOTAL					24,161 m³	

Table 3 shows data for pine logs with length of 6,0 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 54,0 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. The mean diameter of the logs varies from

37,0 to 57,0 cm. Log taper is within the range of 0,3 to 2,50 cm/m. Depending on the diameters of the logs, their volume varies from 0,482 to 1,425 m³ and accordingly assigned in I/III class of quality.

Table 3. Data regarding pine logs, 6,0 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	42,0	36,0	6,0	1,83	0,610	I/III
2	35,0	39,0	37,0	6,0	0,67	0,645	
3	28,0	38,0	33,0	6,0	1,67	0,513	
4	28,0	37,0	32,0	6,0	1,50	0,482	
5	36,0	38,0	37,0	6,0	0,33	0,645	
6	40,0	49,0	44,0	6,0	1,50	0,912	
7	33,0	37,0	40,0	6,0	0,67	0,754	
8	42,0	57,0	49,0	6,0	2,50	1,131	
9	38,0	42,0	40,0	6,0	0,67	0,754	
10	35,0	38,0	36,0	6,0	0,50	0,610	
11	33,0	38,0	35,0	6,0	0,83	0,577	
12	39,0	42,0	40,0	6,0	0,50	0,754	
13	34,0	42,0	38,0	6,0	1,33	0,680	
14	38,0	44,0	41,0	6,0	1,00	0,792	
15	42,0	48,0	45,0	6,0	1,00	0,954	
16	50,0	56,0	53,0	6,0	1,00	1,323	
17	54,0	57,0	55,0	6,0	0,50	1,425	
18	38,0	48,0	43,0	6,0	1,67	0,871	
19	40,0	48,0	44,0	6,0	1,33	0,912	
20	35,0	45,0	40,0	6,0	1,67	0,754	
21	39,0	47,0	43,0	6,0	1,33	0,871	
22	50,0	56,0	53,0	6,0	1,00	1,323	
23	41,0	47,0	44,0	6,0	1,00	0,912	
24	33,0	39,0	36,0	6,0	1,00	0,610	
25	52,0	56,0	54,0	6,0	0,67	1,373	
26	42,0	50,0	46,0	6,0	1,33	0,997	
27	50,0	56,0	53,0	6,0	1,00	1,323	
28	41,0	51,0	46,0	6,0	1,67	0,997	
29	33,0	39,0	36,0	6,0	1,00	0,610	
30	36,0	38,0	37,0	6,0	0,33	0,645	
31	TOTAL					25,759 m³	

3.1 Pine logs 5,0 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, the mean diameter of the log and taper of the log with length of 5,0 m. (Table 4).

Table 4. Statistical data regarding diameter and log of the taper / pine 5,0 m in length

	Mean value	Standard deviation	Coefficient of variation
	$\bar{X}_{sr} \pm f_{xsr}$	$S \pm f_s$	$V \pm f_v$
Diameter of thin end d_1 (cm)	$42,2 \pm 1,427$	$7,815 \pm 1,009$	$18,505 \pm 2,470$
Diameter of thick end d_2 (cm)	$47,9 \pm 1,564$	$8,564 \pm 1,106$	$17,878 \pm 2,381$
Mean diameter d_{sr} (cm)	$44,8 \pm 1,459$	$7,989 \pm 1,031$	$17,832 \pm 2,374$
Log taper S (cm/m)	$1,1 \pm 0,091$	$0,497 \pm 0,064$	$44,390 \pm 6,767$

It can be noticed from Table 4, that the diameter of the thin end is $42,2 \pm 1,427$, with standard deviation of $7,815 \pm 1,009$ and coefficient of variation of $18,505 \pm 2,470$ %.

The mean diameter of the thick end is $47,9 \pm 1,564$ cm, with standard deviation $8,564 \pm 1,106$ and coefficient of variation of $17,878 \pm 2,381$ %.

The mean diameter of the logs is $44,8$ cm $\pm 1,459$ cm, with standard deviation of $7,989 \pm 1,031$ and coefficient of variation of $17,832 \pm 2,374$ %. Taper of the log with I/III class of quality is $1,1 \pm 0,091$ cm/m, standard deviation $0,497 \pm 0,064$ and coefficient of variation of $44,390 \pm 6,767$ %.

3.2 Pine logs 6,0 m in length

The results of the research for logs 6, 0 m (table 3) were statistically analyzed and they are presented in table 5.

Table 5. Statistical data regarding diameter and log of the taper / pine 6,0 m in length

	Mean value	Standard deviation	Coefficient of variation
	$\bar{X}_{sr} \pm f_{xsr}$	$S \pm f_s$	$V \pm f_v$
Diameter of thin end d_1 (cm)	$38,9 \pm 1,240$	$6,791 \pm 0,877$	$17,473 \pm 2,324$
Diameter of thick end d_2 (cm)	$45,5 \pm 1,267$	$6,937 \pm 0,896$	$15,257 \pm 2,015$
Mean diameter d_{sr} (cm)	$42,2 \pm 1,204$	$6,594 \pm 0,851$	$15,625 \pm 2,066$
Log taper S (cm/m)	$1,1 \pm 0,093$	$0,508 \pm 0,066$	$46,177 \pm 7,121$

From the table it can be concluded that the mean value of the thin end for the wood of Pine is $38,9 \pm 1,240$ cm, with standard deviation of $6,791 \pm 0,877$ and coefficient of variation of $17,473 \pm 2,324$ %. The mean value of the thick end is $45,5 \pm 1,267$ cm, the standard deviation is $6,937 \pm 0,896$ and the coefficient of variation is $15,257 \pm 2,015$ %. Further, the mean diameter of the logs has values of $42,2 \pm 1,204$ cm/m, the standard deviation is $6,594 \pm 0,851$ and the coefficient of variation is $15,625 \pm 2,066$ %. The log taper has mean value of $1,1 \pm 0,093$, with standard deviation of $0,508 \pm 0,066$ and coefficient of variation of $46,177 \pm 7,121$ %.

3.3 Comparison of the results for pine logs 5,0 and 6,0 m in length

In order to get comparison of the results obtained, they are shown in Table 6.

Table 6. Statistical data regarding diameter and log of the taper / pine 5,0 and 6,0 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
Pine	I/III	5,0	42,0	48,0	45,0	1,1
		6,0	39,0	46,0	42,0	1,1

From Table 6 we can see that the diameter of the thin end of logs varies from 39,0 cm for 6,0 m length to 42,0 cm for 5,0 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 46,0 cm to 48,0 cm for lengths of 6,0 m and 5,0 m respectively. There is no big difference among the values of mean diameter with logs of both lengths. The values range between 42,0 to 45,0 cm.

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

4. CONCLUSION

1. The raw materials were sawmill logs of 5,0, and 6,0 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 5,0 m logs varied from 28,0 to 53,0 cm and 30,0 to 63,0 cm respectively. The mean diameter (statistically calculated value) was $48,3 \pm 2,38$ cm. The log taper was $1,1 \pm 0,091$ cm/m and belongs to the „C” group of thickness (Table 1).
5. The diameter of the thin and thick end of 6,0 m logs varied from 28,0 to 54,0 cm and 30,0 to 60,0 cm respectively. The mean diameter (statistically calculated value) was $42,2 \pm 1,204$ cm. The log taper was $1,1 \pm 0,093$ cm/m and belongs to the „C” group of thickness (Table 1).
7. The total volume of the log with 5,0 m and 6,0 m in length was $49,92 \text{ m}^3$, $24,161 \text{ m}^3$ and $25,759 \text{ m}^3$ 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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