Original scientific paper
Received:19.03.2021
Accepted:17.10.2021
UDK: 674.82.031.632.2

INFLUENCE OF BEECH SAWLOGS (*Fagus Sylvatica* L.) QUALITY ON MILLED LUMBER QUALITY

Ana Marija Stamenkoska, Branko Rabadziski, Goran Zlateski

Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia,
Faculty of Design and Technologies of Furniture and Interior - Skopje
email: stamenkoska@gmail.com; rabadziski@fdtme.ukim.edu.mk; zlateski@fdtme.ukim.edu.mk

ABSTRACT

This research paper presents results obtained from conducted research under pragmatic conditions. The results correspond to the influence of the sawlogs quality on the milled lumber quality. The logs were from beechwood (*Fagus sylvatica* L.).

The beech sawlogs, as the key point of research, were graded as 1st and 2nd grade logs.

The sawlogs were with the consistent length of l = 4,0 m. The diameter of the 1st grade logs was in the range d = 33,0 ÷ 50 cm, and for the 2nd grade logs d = 34,0 ÷ 50,0 cm. The total number of analyzed logs was 40, 20 logs for each grade. The 1st grade sawlogs had the volume of V = 11,7 m^3 and the volume for the 2nd grade logs was the same, V = 11,7 m^3. The 1st grade sawlogs had a diameter taper in the range S = 0,5 ÷ 1,0 cm/m and the 2nd grade logs' diameter taper was S = 0,75 ÷ 1,75 cm/m. The mean value of the diameter taper was as followed: for the 1st grade logs, S_{sr} = 0,78 cm/m and for the 2nd grade logs S_{sr} = 1,26 cm/m.

It must be noted that the milled lumber values given in this research are relative. After milling the 1st grade logs, the following values were obtained: sawn lumber with a share of 62,80%, dimensional lumber with a share of 18,55%, and heartwood with a share of 18,65%; from a total amount of 100%. The 2nd grade logs gave the following values, from the total amount of 100%: 51,80% sawn lumber; 21,38% dimensional lumber, and 26,82% heartwood.

The dimensional distribution of the milled lumber, for the 1st grade, from the total amount of 100%, was as following: 44,60% long milled lumber (l > 2,0 m); 20,84% short milled lumber (l = 1,0 ÷ 1,90 m); 15,91% extra short milled lumber (l = 0,5 ÷ 1,0 m) and 18,65% heartwood. The 2nd grade milled lumber had the following dimensional distribution: 38,20% long milled lumber (l > 2,0 m); 14,76% short milled lumber (l = 1,0 ÷ 1,90 m); 20,22% extra short milled lumber (l = 0,5 ÷ 1,0 m) and 26,82% heartwood, from the total amount of 100%.

Keywords: milling, beech, sawlogs, sawn lumber, quality, quality utilization.

1. INTRODUCTION

The prosperity of the sawmilling manufacturing process is considerably and predominantly dependable on the quantitative and qualitative utilization of the sawlogs.

Access to applicable data from this industry is difficult, so therefore the milling process should have definite more straightforward and precise systems divided into phases and operations. This is crucial for the manufacturing process to run steadily.

This paper emphasizes qualitative utilization of sawlogs in relation to the total amount of milled lumber, separating the lumber by quality grades and length groups.

2. AIM OF RESEARCH

Through this research, an attempt was made to examine the qualitative utilization of milled lumber obtained from beech sawlogs, and as mentioned, all given values of the parameters are relative.

3. RESEARCH METHODS

The results were obtained using conventional and accurate mathematical formulas for calculating the volume of the sawlogs and milled lumber.

The different percentages of the partitions of lumber that take part in the total percentage of milled lumber were obtained by a relative correlation between the single milled lumber and the total amount of milled lumber. The results are shown systematically by tables and histograms. This research method was carried out as per the Macedonian standards МКС EN Д.Б4.028/1:1990 and МКС EN Д.Ц1.022.

4. RESULTS AND DISCUSSION

The total number of analyzed sawlogs was 40 and they were with a consistent length of l = 4,0 m.

Table 1 shows the parameters of the sawlogs graded within the 1st grade, with a count number of 20. The sum volume of this group of logs was V = 11,7 m^3. The smallest value of the diameter from this group was d_{min} = 33,0 cm, the greatest d_{max} = 50,0 cm, and the mean value of the diameter was in the range dsr = 34,0 ÷ 49,0 cm.

Table 1. *Parameters of the 1st grade beech sawlogs*

Count number	Diameter of the narrower log end	Diameter of the wider log end	Mean diameter	Length	Volume	Total number of sawlogs
	d_1 (cm)	d_2 (cm)	d_{sr} (cm)	l (cm)	V (m^3)	N
1	2	3	4	5	6	7
1	33,0	35,0	34,0	4,0	0,364	20
2	38,0	41,0	40,0		0,502	
3	42,0	48,0	45,0		0,636	
4	39,0	43,0	41,0		0,527	
5	39,0	44,0	42,0		0,554	
6	39,0	44,0	42,0		0,554	
7	35,0	39,0	37,0		0,430	
8	46,0	50,0	48,0		0,723	
9	48,0	50,0	49,0		0,754	
10	41,0	44,0	43,0		0,581	
11	46,0	49,0	48,0		0,723	
12	36,0	38,0	37,0		0,430	
13	41,0	43,0	42,0		0,554	
14	45,0	48,0	47,0		0,694	
15	48,0	50,0	49,0		0,754	
16	48,0	50,0	49,0		0,754	
17	36,0	40,0	38,0		0,453	
18	38,0	40,0	39,0		0,478	
19	44,0	46,0	45,0		0,636	
20	42,0	44,0	43,0		0,581	
21	Total sawlogs volume: Σ_1 = 11,682 $m^3 \approx$ 11,7 m^3					

Table 2 shows the values of the sawlogs graded as 2nd grade logs. There were 20 analyzed logs with a total volume of V = 11,7 m^3. Within this group, the smallest value of the log diameter was d_{min} = 34,0 cm, and the greatest value was measured as d_{max} = 50,0 cm. The range value for the mean diameter of the 2nd grade logs was d_{sr} = 37,0 ÷ 48,0 cm.

Table 2. *Parameters of the 2nd grade beech sawlogs*

Count number	Diameter of the narrower log end	Diameter of the wider log end	Mean diameter	Length	Volume	Total number of sawlogs
	d_1 (cm)	d_2 (cm)	d_{sr} (cm)	l (cm)	V (m^3)	N
1	2	3	4	5	6	7
1	45,0	50,0	48,0	4,0	0,723	
2	40,0	47,0	44,0		0,608	
3	40,0	47,0	44,0		0,608	
4	39,0	45,0	42,0		0,554	
5	43,0	48,0	46,0		0,664	
6	46,0	49,0	48,0		0,723	
7	39,0	44,0	42,0		0,554	
8	45,0	50,0	48,0		0,723	
9	45,0	50,0	48,0		0,723	
10	40,0	46,0	43,0		0,581	
11	35,0	41,0	38,0		0,453	
12	37,0	42,0	40,0		0,502	
13	43,0	47,0	45,0		0,636	
14	40,0	44,0	42,0		0,554	
15	45,0	50,0	48,0		0,723	
16	34,0	40,0	37,0		0,430	
17	35,0	40,0	38,0		0,453	
18	37,0	40,0	39,0		0,478	
19	40,0	43,0	42,0		0,554	
20	34,0	40,0	37,0		0,430	
21	Total sawlogs volume: Σ_2 = 11,674 $m^3 \approx$ 11,7 m^3					

According to the data given in tables 1 and 2, and in correlation with the grade class of the sawlogs, the next crucial parameter that was analyzed was the log diameter taper (S). The log diameter taper is one of the lumber peculiarities with the greatest importance for qualitative utilization. Corresponding to this parameter, the lumber is graded within the 1st or 2nd grade. The values of the log diameter taper for logs analysis are given in table 3.

Table 3*. Log diameter taper for the 1st and 2nd grade logs*

Quality class	Log diameter	Log length	Log diameter taper	Mean log diameter taper
K	d (cm)	l (m)	s (cm/m)	s_{sr} (cm/m)
1st grade	33,0 ÷ 50,0	4,0	0,5 ÷ 1,5	0,78
2nd grade	34,0 ÷ 50,0		0,75 ÷ 1,75	1,26

From the given values above, it can be concluded that the log diameter taper for the 1st grade logs was within the range S = 0,5 ÷ 1,5 cm/m, and the mean value was S_{sr} = 0,78 cm/m. For the 2nd grade sawlogs, the log diameter taper was calculated within the range S = 0,75 ÷ 1,75 cm/m, and the mean value was S_{sr} = 1,26 cm/m.

The partitions of milled lumber from the 1st and 2nd quality logs are given in table 4. The percentage of the partitions was obtained after milling the sawlogs into dimensional and sawn lumber, and the amount of lumber left from the heartwood. Dimensional lumber is characterized as lumber with smaller dimensions, often used for parquet plies and lamellas. Sawn lumber is defined by the: unedged, partially edged, and edged planks and boards, beams and columns, wooden railways, etc.

Table 4. *Partitions of milled lumber*

Count number	Milled lumber	The quality grade of the sawlogs	
		1st grade	2nd grade
	N	K (%)	
1	Sawn lumber	62,80	51,80
2	Dimensional lumber	18,55	21,38
3	Heartwood	18,65	26,82
4	Total (Σ_{1+2+3})	100	100

From the given values, a conclusion can be drawn that the milled lumber from the 1st grade logs was with the following partitions in the total percentage of 100%: 62,80% sawn lumber, 18,55% dimensional lumber, and 18,65% heartwood. For the 2nd grade logs, the partitions were as followed: 51,80% sawn lumber, 21,38% dimensional lumber, and 26,82% heartwood, from the total amount of 100%.

The values from table 4 are shown with the histogram in figure 1.

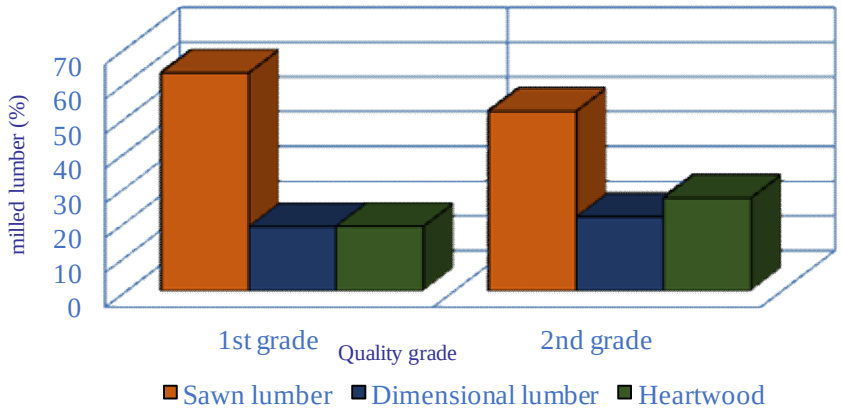

Figure 1. *Correlation between the quality grade and the milled lumber*

The dimensional distribution of milled lumber, depending on the quality grade and the length of lumber, is given in table 5.

Table 5. *Dimensional distribution of milled lumber in length groups*

Count number	Milled lumber	The quality grade of the sawlogs	
		1st grade	2nd grade
	N	K (%)	
1	Long milled lumber (l > 2,0 m)	44,60	38,20
2	Short milled lumber (l = 1,0 ÷ 1,90 m)	20,84	14,76
3	Extra short milled lumber (l = 0,5 ÷ 1,0 m)	15,91	20,22
4	Heartwood	18,65	26,82
5	Sum total (Σ_{1+2+3})	100	100

Table 5 gives the conclusion that quality grade is of substantial significance for different partitions of milled lumber, according to the length, for the different groups (long, short, extra short milled lumber and heartwood). From the data above, it can be concluded that with the higher-grade sawlogs (1st grade) a greater percentage of longer milled lumber is obtained. The histogram in figure 2 shows this conclusion.

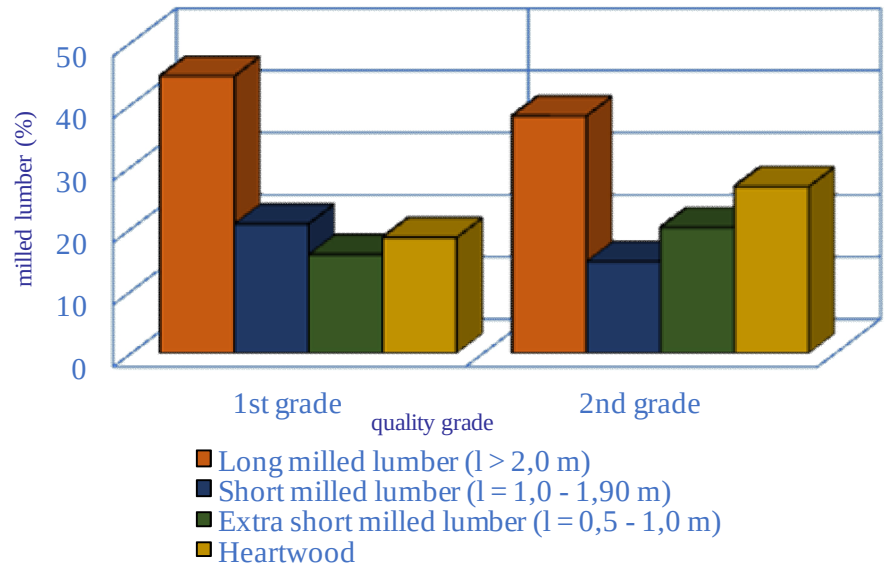

Figure 2. *Correlation between the quality grade and dimensional distribution of milled lumber in length groups*

5. CONCLUSION

This paper gives the results of analysis of the relation between the quality grade of beech sawlogs and the quality of milled lumber. The quality of the milled lumber defines the dimensional distribution within length groups.

According to the conducted research under manufacturing conditions in a sawmill, the following conclusions can be drawn:

1. Research material: beech sawlogs.
2. Sawlogs' parameters:
   - length: l = 4,0 m;
   - 1st grade sawlogs diameter: d = 33,0 ÷ 50,0 cm;
   - 2nd grade sawlogs diameter: d = 34,0 ÷ 50,0 cm;
   - quality grade: 1st and 2nd.
3. Total number of sawlogs: 20 within each grade, 40 total.
4. The volume of the 1st grade sawlogs was V = 11,7 m^3, the same as the 2nd grade logs.
5. The log diameter taper for the 1st grade logs was in the range S = 0,5 ÷ 1,5 cm/m, with mean value of S_{sr} = 0,78 cm/m.
6. The log diameter taper of the 2nd grade sawlogs was in the range S = 0,75 ÷ 1,75 cm/m, with mean value of S_{sr} = 1,26 cm/m.
7. Partitions of the milled lumber:
   7.1 1st grade:
      a) sawn lumber = 62,80%;
      b) dimensional lumber = 18,55%;
      c) heartwood = 18,65%;
      Total Σ_{1+2+3}: 100 %.
   7.2. 2nd grade:
      a) sawn lumber = 51,80%;
      b) dimensional lumber = 21,38%;

c) heartwood = 26,82%;
Sum total Σ_{1+2+3}: 100 %.

8. Dimensional distribution of the milled lumber in length groups:
   8.1. 1st grade:
      a) long milled lumber (l > 2,0 m) = 44,60%;
      b) short milled lumber (l = 1,0 ÷ 1,90 m) = 20,84%;
      c) extra short milled lumber (l = 0,5 ÷ 1,0 m) = 15,91%;
      d) heartwood = 18,65%;
      Sum total Σ_{1+2+3}: 100 %.
   8.1. 2nd grade:
      a) long milled lumber (l > 2,0 m) = 38,20%;
      b) short milled lumber (l = 1,0 ÷ 1,90 m) = 14,76%;
      c) extra short milled lumber (l = 0,5 ÷ 1,0 m) = 20,22%;
      d) heartwood = 26,82%;
      Sum total Σ_{1+2+3}: 100 %.

REFERENCES

[1] Krutel, F. (1983): Use of beechwood in sawmilling depending on the sawlog quality, Bilten ZIDI, 11 (3): 26 – 38 (in Croatian).
[2] Macedonian standards – MKS, 1995.
[3] Rabadziski, B. (2018): Sawmilling technology Workbook, Faculty of Design and Technologies of furniture and interior, Skopje, Republic of North Macedonia (in Macedonian).
[4] Rabadziski, B. (2019): Sawmilling technology, Faculty of Design and Technologies of furniture and interior, Skopje, Republic of North Macedonia (in Macedonian).
[5] Rabadziski, B., Zlateski, G., Krstev, M., Stamenkoska, A.M.: Analysis of the influence of beech sawmill logs length on maximum quantity exploitation, Proceedings of the 5th International Scientific Conference of "Wood Technology and Product Design", 14th – 17th September, 2021, Ohrid: 187 – 197.

Web sources:
- www.drvotehnika.info
- www.pilanarstvo.com
- www.woodmizer.hr

The Authors' Address:

[1] dip. Ing. Ana Marija Stamenkoska, Master student; Dr. Ing. Branko Rabadziski, full professor; Dr. Ing. Goran Zlateski, full professor.
[1]Department of Primary Wood Processing, Faculty of Design and Technologies of Furniture and Interior – Skopje, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia, 16ra Makedonsa brigada 3, PO box 223, 1000 Skopje, North Macedonia.