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ANALYSIS OF PIECE BY PIECE METHODS OF ROUND WOOD MEASUREMENTS AND VOLUME ESTIMATION

Based on literature review piece by piece methods of round wood measurements employed in different countries are briefly discussed. The main working method of upper diameter (STB 1667-2012, GOST 2708–75) was researched (in comparison with the control data of formulas Smaliana and a truncated cone). An analysis of round wood volume tables from GOST 2708–75 in comparison with control data showed positive values of deviations that indicates larger values in standard volumes (GOST 2708–75) (up to 13% for medium-sized (24 cm) and large (over 24 cm) round wood). However, for logs with taper coefficient more than 1 cm/m negative deviations are characterized, which, in turn, suggests an underestimation of wood volume in the standard tables in relation to the control data of formulas Smaliana and truncated cone (–18%). Formula Smaliana versus frustoconical formula underestimates the timber volume (however, not more than 1%). Obviously, both of these formulas can be used to determine the amount of measurement errors by the method of upper diameter. In our view, it is advisable to clarify the method of upper diameter based on the average value of taper coefficient in stacked batches of round wood (entering of amendments to the volumes from GOST 2708–75 on a log taper coefficient of real value).

Key words: roundwood, measurement methods, piece by piece methods, method of the upper diameter, method of the end sections, volume deviations.

Introduction. In accordance with the Decree of the President of Belarus Alexander Lukashenko no. 504 “On amendments and additions to the Presidential Decree of May 7, 2007 no. 214 and September 9, 2009 no. 444” transition to the use of harvested wood is supposed to be done [1]. In view of the transition in the forestry sector to the selling of harvested timber, the establishing an effective transparent system of accounting and monitoring of timber motion, studying statistical significance of the results of accounting gets even more acute. Inventory errors of harvested timber, unguided by the fieldworkers themselves, lead to a significant loss of the seller or buyer of wood (the formation of “unreported income” as the difference of the actual and recorded volumes), the unreliability of the results taking into account the volume of roundwood at different stages of their registration, an imbalance in the account of roundwood warehouses [2, 3]. Improving timber accounting system is also important in terms of its compliance with the international standards and requirements as the export potential of the Belarusian forests will increase. Due to the fact that the Belarusian standard STB 1667-2012 corresponds to the European standard EN 1309-2: 2006 “Round and sawn timber. Method of measurement of dimensions. Part 2: Round timber. Requirements for measurement and volume calculation rules”, the research will have practical significance for the harmonization of regulations according to accounting round timber [4].

The aim of this research is the theoretical study and practical substantiation of piecemeal methods of taxation of round timber with the determining

their limit errors depending on the measurement technology. The purpose of the research is to analyze wood accounting systems in our country and abroad; analyze the working method of the errors “Upper diameter with a certain volume of round timber according to the base table (for “butt and middle timber”) GOST 2708-75”; practical substantiation of the possibility of using the piecemeal measurement methods and determine the volume of harvested timber. This paper presents an analysis of the errors of the upper limit diameter of the working method. Method of two sections (with the calculation of volume by the formula of Smalian (according to STB 1667-2012), as well as on the basis of Lithuanian, Polish and Swedish experience with the calculation of volume according to the formula of a truncated cone) was used as a “control method” of the group of piecemeal ones.

The paper presents the interim results of the study, preliminary findings are substantiated sufficiently by the large volume of field experimental data.

Main part. The analysis of foreign experience [2, 3, 5–8] was performed. Thus, we can conclude that in many countries, taking into account the harvested timber similar methods as described in our standard STB 1667-2012 are used. Finland, Poland, Russia, Ukraine – upper diameter method. Sweden – the top, middle, vertex-butt measurement according to the measurement sections (similar to the methods of the upper diameter of the middle section, two sections/cuts, sectional method, respectively). Lithuania – methods of upper or median diameter, of two sections/cuts. However, unlike the domestic experience in Poland while taking into

account the upper diameter of timber the value of the average run-out in measured party of timber is also taken into account; in Finland automated accounting systems – harvester records data (using a regular calibration technology reader of the harvester mechanism), a special scanning line on wood-processing enterprises, the tables of volumes of logs are made taking into account the average run-out logs (for certain regions of the country) are widely used; in Lithuania, Poland, Sweden, the formula of a truncated cone (in the Belarusian standard Smalian's formula is proposed) is used as a method of two sections. In Canada, the methods differ from the methods of accounting of harvested wood in our country, – volume method, the method of tree length, grading method are used. In our country, in the “forest conditions” (according to the instructions on accounting of timber a forest master (or other authorized person) carries out measurement) a top-diameter method is used (from the group of the piecemeal timber accounting methods (according to STB 1667-2012)).

The methodology of this study involves the analysis of the piecemeal round timber inventory techniques. To calculate the volume of timber its diameter and length are measured. The length of

the log is measured by the shortest distance between the ends of the logs in meters rounded to 0.01 m. The diameter of the log is determined in centimeters as the arithmetic mean of the measurements of two mutually perpendicular diameters (measured in centimeters up to 0.1 cm, rounded to 2 cm steps according to the GOST 2292–88, GOST 2708–75) [4]. Thus, according to the results of field measurements the volume of logs is determined according to the diameter of the upper method, of two sections (with the calculation of volume by the formula of Smalin and a truncated cone). Measurements are performed on the lower stock of the branch of Minsk furniture center in the town of Krupsky, stock of raw material in the wood-working shop of Negorelsky experimental forestry, Molodechno, Vileika forestries, lower stock of Krupsk forestry. At the moment the results of measurements of 446 saw logs are processed. The volumes of logs are calculated in accordance with GOST 2708–75 tables, formula of two sections (Smalian) [4] and the formula of a truncated cone.

On the basis of the calculation of volume of timber, deviation volumes by the Tables of GOST 2708–75 relative to the formula of two sections/cuts and a truncated cone (Tables 1, 2) were identified.

Table 1

**Flaws in determining the volume of timber
in accordance with GOST 2708–75 in comparison with the data of the method of two sections
(formula of end sections (Smalian))**

Diameter of timber, cm	Deviations with respect to the formula of two sections at a value of runout (cm/m), %								
	up to 0.79			0.80–1.19			more than 1.20		
	max	min	avg	max	min	avg	max	min	avg
13–14	9.35	–5.64	1.42	–11.63	–6.79	–9.89	–	–	–
16	16.19	–9.55	3.25	–15.25	–7.43	–11.27	–17.98	–16.23	–17.10
18	21.18	–8.43	6.51	–11.97	–1.90	–7.05	–21.79	–5.83	–13.64
20	19.91	–4.35	5.92	–5.28	1.91	–1.92	–15.44	–7.74	–12.22
22	15.31	–6.49	4.64	–7.90	4.68	–3.35	–20.28	–10.0	–15.41
24	13.17	–5.84	3.53	–3.93	5.15	–1.11	–18.57	–8.22	–14.88
26	18.07	–1.08	8.59	–5.06	4.07	–1.03	–7.59	–4.09	–5.84
28	22.02	–0.95	8.96	2.48	–1.48	0.34	–20.46	–1.90	–10.51
30	22.40	1.33	9.05	7.59	–4.12	2.13	–18.33	–1.08	–11.31
32	23.04	0.08	11.78	8.47	–0.65	2.24	–17.79	–4.85	–12.58
34	22.07	1.48	9.98	9.58	–2.50	2.46	–14.19	1.07	–8.12
36	22.87	6.22	12.84	11.37	2.72	7.95	–14.48	2.15	–6.84
38	17.57	5.68	12.63	7.54	4.79	6.38	–10.22	–2.42	–6.88
40	17.59	4.14	11.99	10.23	0.12	5.56	–8.65	0.35	–4.34
42–48	15.12	4.79	9.15	8.25	0.39	4.27	–15.00	6.69	–6.09

Note: max – maximum value; min – minimal value; avg – average value.

Table 2

**Flaws in determining the volume of logs
in accordance with GOST 2708–75 in comparison with the data of the method of two sections
(formula of of a truncated cone)**

Diameter of timber, cm	Deviations with respect to the formula of a truncated cone at a value of runout (cm/m), %								
	up to 0.79			0.80–1.19			more than 1.20		
	max	min	avg	max	min	avg	max	min	avg
14	9.11	–6.00	1.09	–12.31	–7.51	–10.63	–	–	–
16	16.14	–9.83	3.01	–16.06	–7.95	–11.85	–18.94	–16.91	–17.92
18	21.06	–8.65	6.28	–12.43	–2.21	–7.63	–22.97	–6.86	–14.78
20	19.81	–4.56	5.78	–6.01	1.40	–2.50	–16.63	–8.68	–13.21
22	15.08	–6.65	4.40	–8.31	4.30	–3.76	–20.96	–10.51	–16.07
24	12.96	–6.08	3.37	–9.74	4.81	–1.49	–19.27	–8.57	–15.43
26	17.97	–1.29	8.44	–5.38	3.76	–1.39	–8.34	–4.61	–6.48
28	21.97	–1.16	8.82	2.27	–1.88	0.03	–21.21	–2.40	–11.09
30	22.35	1.14	8.93	7.32	–4.47	1.85	–19.11	–1.48	–11.96
32	23.02	–0.06	11.68	8.27	–0.94	2.02	–18.46	–5.24	–13.19
34	22.06	1.36	9.90	9.38	–2.78	2.24	–14.74	0.88	–8.59
36	22.86	6.16	12.78	11.19	2.58	7.78	–15.31	1.94	–7.30
38	17.56	5.60	12.57	7.41	4.59	6.20	–10.86	–2.58	–7.32
40	17.59	4.05	11.93	10.08	–0.02	5.41	–9.09	0.03	–4.69
42–46	15.05	4.71	9.09	8.12	0.25	4.13	–15.55	6.50	–6.48

Based on the above results (Table 1) we can conclude that for the large timber (more than 24 cm) at runout of 0.8–1.2 cm/m average deviations are mostly within $\pm 7\%$ (greater than $\pm 5\%$ level); for medium timber (up to 24 cm) at runout of 0.8 cm/m average deviations are within $\pm 7\%$, they are significantly higher than the value at $\pm 5\%$ (as $\pm 7\%$ greater) for large timber. At runout more than 1.2 cm/m for medium and large timber the average deviation values exceed $\pm 5\%$ level of error.

The results of inventory data error estimates of timber volume by using the tables to GOST 2708–75 with respect to the formula of a truncated cone in general repeat the results of calculating deviations of data with respect to the formula of two sections (Smalian) (Table 2).

Conclusion. By analyzing the nature of deviations it is concluded that the volume of timber at runouts more than 1.2 cm/m are generally characterized by negative values of the deviations (i. e. values by the tables of the state standard are less than the calculated amounts by the control formulas). The average values of the deviations exceed the permissible value $\pm 5\%$, and range from –4 to –18 both by Smalian formula and the formula of the truncated cone (Tables 1 and 2). If we consider the timber at runout of up to 1 cm/m, in com-

parison with the formula of control methods (the deviation is from 1 to 13%) for this category the excess of the table values (according to the standard volume tables) it observed.

Our data also indicate that Smalian formula compared with the truncated cone formula underestimates the volume of timber harvested, but not more than 1%. Obviously, these formula can be used to determine the errors of measurement in the volume of timber by the upper circular diameter. At the same time, in this case, we recommend the method of end sections with calculation of volume of logs based on a formula of volume of a truncated cone to be used.

Thus, it is advisable to clarify the method of the upper diameter, taking into account the value of the average runout in the batches of measured round timber (amending the amounts of the table of GOST 2708–75 on the real value of runout). To establish the correction factors for runout of logs in the method of the upper diameter a sample piecemeal measuring method of the end sections (Smalian formula or formula for the volume of a truncated cone) can be used, which is one of the most precise “manual” piecemeal methods to determine the volume of logs, as it allows to take into account a runout of each logs. It is obvious that very soon the upper diameter

method (from the group of piecemeal methods according to STB 1667-2012), as well as stacking (geometric) method (group methods) will remain the most popular working methods of harvested timber.

Random piecemeal measurements by two sections method are suitable for establishing correction factors on a runout of logs at the piecemeal dimensions by the top diameter, the average volume of the log in the measurement volume of the harvested batch of wood by the “group method” on

the number of logs, the volume measurement error of harvested wood by the top diameter working method, as well as to clarify, if necessary, full-tree factors in measuring the volume of a batch of harvested timber by the stacking method. Probably, it is advisable to consider the use of a more precise method of accounting for the end sections of high quality saw logs and veneer logs of hardwoods, birch plywood as well as the first-class raw materials, which are in high demand.

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