METHODS OF SELECTION AND DATA PROCESSING AT THE ELECTRONIC MEASUREMENT OF LOG DIMENSIONS AND THEIR EFFECT ON THE EVALUATED DIOMENSIONS AND VOLUME

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Abstract

Procedures used at the electronic reception differ from each other by the place and method of the measurement of log diameter and by procedures at the calculation of volume. Thus, differences occur between results of both manual and electronic determination of dimensions and volumes and between particular methods of the electronic measurement. The paper selects methods of the electronic measurement used most often in the Czech Republic (Recommended rules 2008, ÖN L 1021 Austrian standard and a German general agreement on the measurement of wood) comparing results achieved by them of the determination of volume partly with manual measurement according to the ČSN 48 0050 standard corresponding to the conventional method of Huber and partly with the geometrical volume of logs determined as accurate as possible. Thus, it appears that all methods used on business show lower volumes of logs as compared with their geometrical dimensions.

Key words: *electronic reception, log measurement, log yards, volume calculation, cubage calculation, wood volume*

INTRODUCTION

At present, the electronic reception of raw material appears to be a. The use of various algorithms of the log volume calculation is a long-time practice too. Their development was considerably affected by commercial interests of users, viz. producers, manufacturers and raw material dealers (forest owners or subdealers - trading companies) or its processors, mainly sawmills.

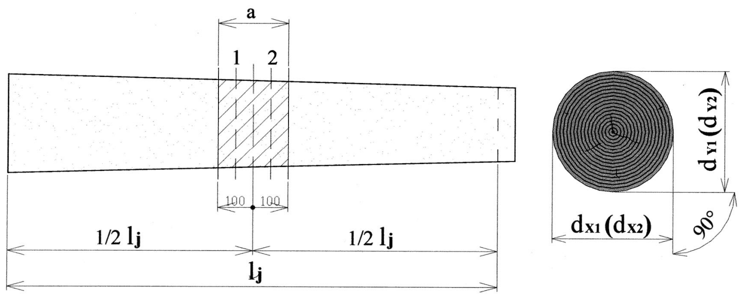
Log dealers are interest in achieving the volume of raw material as high as possible, however, buyers, as low as possible. With respect to the higher concentration of timber production than forest production the majority of devices for the electronic reception of wood occurs on the area of sawmills and, thus, a trend predominates to undermeasure the actual volume of raw material (i.e. a value of the log volume obtained by means of electronic measurement is lower than the actual geometrical volume of logs).

This effort is reasoned by utilizable dimensions of logs. Results of measurements are, however, given as log volume and not as its utilizable part. Excess measuring the logs (ie obtaining the higher value of volume than the actual geometrical volume of logs) is not usual and with the exception of engineering deficiencies of the equipment it does not occur.

A legislative standard, which would determine obligatorily the unified algorithm of the calculation of log dimensions from taken values and as well the calculation of volume does not exist in any country of Central Europe. It is not also probable that it would be accepted in the near future. Algorithms used in the practice of Central European countries stem from one Huber's method. The volume of a log is determined as the volume of a cylinder the diameter of which is the mid diameter of a log and its length is equal to the nominal length of a log. Markedly more accurate determination of the log volume by length sections is not used in practice anywhere.

The method was described by Huber, however, he rejected the procedure for its high difficulty and practical infeasibility in forest (manual measurements). Thus, differences between methods of the volume determination consist exclusively in the determination of mid diameter.

Most of devices work by a method, which is identical or near the Austrian L 1021 standard. This standard defines the mid diameter by means of measurements carried out on two places of a "measuring section". Places of measurement are 10 cm apart; the centre of nominal length is situated between them. At each of the places, the diameter is measured at least in two perpendicular directions. Particular measurements are expressed in cm in such a way that mm are not taken into consideration. In each of the measuring places, an arithmetical mean is calculated from both values and the result is expressed in cm in such a way that mm are not considered. Mid diameter is equal to the smaller one from the values obtained.



l_j – nominal length

a – measuring p

1, 2 – measuring places,

d_{X1}, d_{Y1}, d_{X2}, d_{Y2} – measured values of diameters

d_1, d_2 – calculated values of diameters in places of measurement

$$d_1 = \frac{d_{X1} + d_{Y1}}{2}, \quad d_2 = \frac{d_{X2} + d_{Y2}}{2}$$

Fig. 1 Determination of a mid diameter

The determination of mid diameter is also consistently prescribed by "Recommended rules for measuring and classifying wood in the Czech Republic 2002". This procedure is always often used.

The same standard ÖN L 1021 makes possible to leave all measured values in mm as well as calculated mean values and volume to calculate from the resulting value in mm. In practice, however, no mill is known in Austria, which would use this possibility (the mid log diameters obtained in this way and thus also its volume is necessarily higher). In the Czech Republic, there is several (older) devices operating in this way, however, results of their measurements are not used for electronic reception, but in-house (handling, registration).

At present in the Czech Republic, there is the most widespread measurement corresponding to up-to-dated "Recommended rules for measuring and classifying wood in the Czech Republic 2008". The mid diameter is determined there as a mean value from measurements on two places in the measuring section. Between the places, the centre of the log nominal length lies (see Fig. 1). Thus, the rules approached a step further the actual geometrical log volume.

A German rule "Rahmenvereinbarung für die Werksvermessung von Stamholz" (General agreement for the measurement of stem wood in a sawmill) is used mainly in Germany but not as the only one. In the Czech Republic, it is not virtually used by wood processors at all; however, it is used by suppliers exporting wood to Germany. The mid diameter is determined similarly as by using "Recommended rules 2008". A difference consists in leaving particular measured log diameter values in mm in logs < 20 cm diameter. Besides, if it is not possible to determine the mid diameter measurement in the centre of a nominal length or to determine it by linear interpolation, values measured near the log butt end are used for the calculation.

Electronic methods of the measurement of dimensions and calculation of the log volume are virtually always compared with manual measurements carried out in forest. In the Czech Republic, there is a conventional instruction, viz. the ČSN 48 00 50 standard – Rough wood – basic and common regulation (1990). The standard determines the measurement of log diameter in the centre of a total (not nominal) length twice perpendicular each other. The measured values are rounded to whole cm mathematically, i.e. values < 0.5 cm down and values ≥ 0.5 cm up. The mid diameter is calculated as the arithmetic mean of measured values being rounded in the same way as particular measurements.

The aim of the paper is to compare results, i.e. log volumes obtained by methods mentioned above to determine relationships between these results and to try to determine procedures enabling the mutual conversion of results.

METHODS

For the purpose of comparisons, values were used on more than 8000 logs within the length range of 3 – 14 m and diameters 16 to 50 cm. Data include values of diameters in mm after filtration taken by every 10 cm log length twice perpendicular each other and values of the total and nominal length.

To determine conversion relationships between particular methods, regression analysis was used. The task consisted in determining a suitable linear model of the given dependence and to calculate its parameters. To estimate parameters of the regression model the method of least squares was used.

Methods compared

Basic comparative methods are as follows:

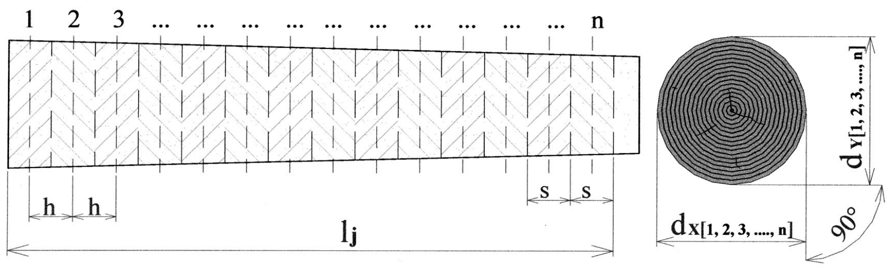
- the ČSN 48 0050 standard – manual measurement (conventional method)
- Recommended rules for measuring and classifying wood in the Czech Republic 2008 – electronic measurement

- Recommended rules for measuring and classifying wood in the Czech Republic 2002 – electronic measurement
- Austrian standard ÖNorm L 1021
- German instruction "Rahmenvereinbarung für die Werksvermessung von Stamholz" (General agreement for the measurement of stem wood in a sawmill)

Methods are described in previous text.

A method by sections is determined as a comparative method. This method makes possible to determine the geometrical volume of logs as accurate as possible without allowance for length. The total log length given in cm is reduced by the value of allowance being rounded to the nearest lower degree of a nominal length. Values of the log diameter are based on carried out measurements (horizontally and vertically at an interval of 10 cm accurate to mm). The log is divided to sections, the length of which corresponds to the length step of the diameter measurement – 10 cm. The section diameter is the arithmetical mean of both ⊥ measurements in the section measuring place. The section volume is equal to the volume of a cylinder of 10 cm length and diameter equal to the section diameter.

The log volume is the sum of volumes of particular sections.



l_j – nominal length
h – spacing of particular measurements (10 cm)
s – section length (10 cm)
$d_{X1}, d_{Y1}, d_{X2}, d_{Y2}, ..., d_{Xn}, d_{Yn}$ – measured values of diameters

Fig. 2 Volume determination by a comparative method

$$d_1 = \frac{d_{X1} + d_{Y1}}{2}, \quad d_2 = \frac{d_{X2} + d_{Y2}}{2}, \dots \quad d_n = \frac{d_{Xn} + d_{Yn}}{2}$$

$$V_1 = \frac{\pi \times d_1^2}{40000} \times s, \quad V_2 = \frac{\pi \times d_2^2}{40000} \times s, \dots \quad V_n = \frac{\pi \times d_n^2}{40000} \times s$$

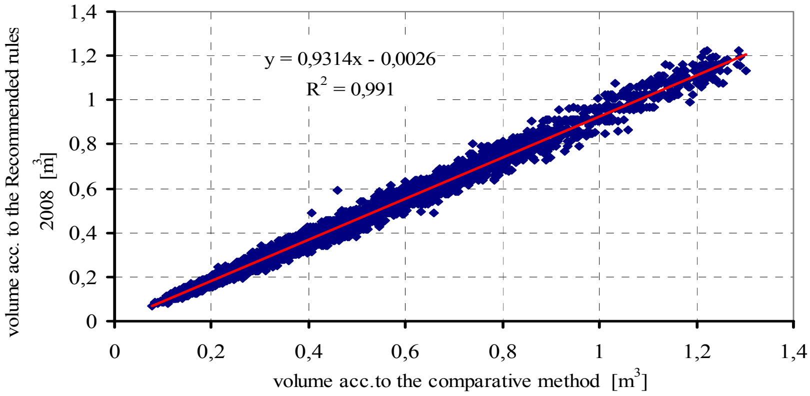
$$V = V_1 + V_2 + \dots + V_n$$

where V – log volume [m^3]
V_1 – section volume [m^3]
$d_1, d_2, \dots d_n$ – mid diameters of sections [cm]
$d_{X1}, d_{Y1}, d_{X2}, d_{Y2}, ..., d_{Xn}, d_{Yn}$ – measured values of diameters [cm]

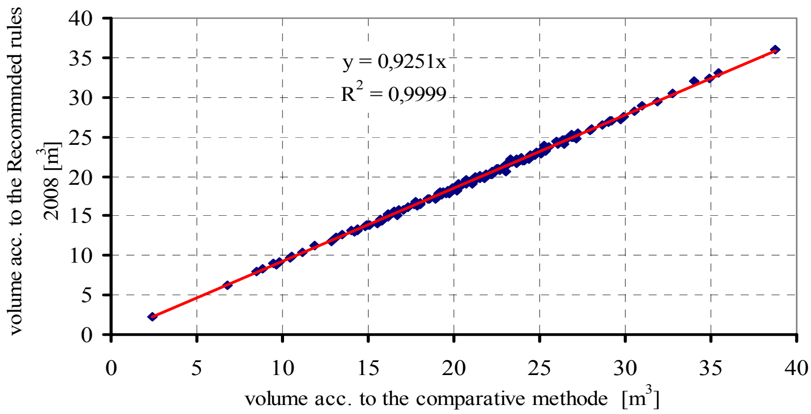
RESULTS AND DISCUSSION

Results of 152 deliveries of the total number of 8 029 logs were evaluated. Relationships between the volume of raw material, calculation by a comparative method and other methods are evaluated from values of deliveries and values of logs. The reason consists in a fact that at the reception of logs, the whole delivery serves usually as a delivery unit and not a particular log.

At present, "Recommended rules for measuring and classifying wood in the Czech Republic 2008" serve as the current method of log reception in the Czech Republic. Relationships between the volume determined according to these rules and a comparative method are as follows:



a) From values of logs



b) From values of deliveries

Fig. 3 Relationships between the volume of raw material calculated according to a comparative method (horizontal x-axis) and Recommended rules 2008 (vertical y-axis)

All other methods mentioned above were evaluated in the same way. For the possibility of a simple conversion relationships were converted so not include an absolute term. The equation of linear regression *Y* = *A* + *BX* was thus simplified to *Y* = *BX*. In principle, conversion coefficients were the results of this procedure.

Tab. 1 Relationships for conversion between a comparative method and other methods according to values of deliveries

The form of the linear regression equation: Y = BX			
Y	*B*	*X*	*Reliability*
ČSN 48 0050 standard - Manual measurement	0.9807	comparative method	0.9999
Recommended rules 2008	0.9251	comparative method	0.9999
Recommended rules 2002, ÖNorm L 1021 (cm)	0.9146	comparative method	0.9999
ÖNorm L 1021 (mm)	0.9613	comparative method	0.9999
Rahmenvereinbarung für die Werksvermessung von Stamholz	0.9302	comparative method	0.9999

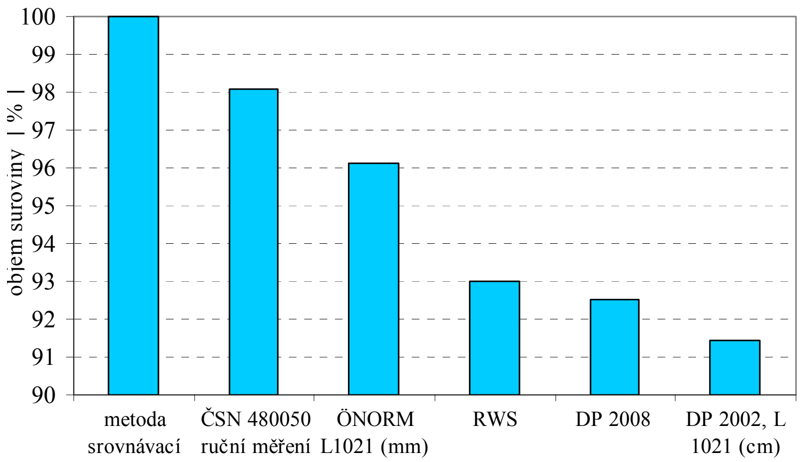


Fig. 4 Graphical demonstration of a percentage difference between the raw material volumes calculated according to the comparative method and other methods according to values of deliveries

Through the analysis of dependences according to logs the dependence of regression relationship was proved on the diameter and length of logs. The direction of dependence is different according to the method used. At the same time, the general expression of this dependence on the log diameter is rather problematic (according to particular methods of measurement it is necessary to assign various diameter to the same log). Particular dependences are rather unclear being unsuitable for practical use. Moreover, reliability of these dependences is markedly lower. Nevertheless, it is necessary to pay attention to this problem.

Calculated differences result only from 2D measurements, i.e. occurring in two ⊥ and predetermined directions. Other differences result from the use of 3D sensing. Its users utilize the standard formulation “measurements in two ⊥ directions” in such a way that they take the whole circumferential curve of a log and look for the smallest value of a diameter in the given place of measurement and its direction. Subsequently, they determine perpendicular direction and the value of a respective diameter. The mean diameter of a log in the given place calculated from basic data obtained in this way is always smaller (at most equal) than a value obtained by means of 2D measurements and, thus, the rule is observed (in light of law).

CONCLUSION

Methods of sensing log dimensions used at various methods of the electronic reception of logs in the Czech Republic, Germany and Austria nearly do not differ from each other even by the accuracy of sensing or by sections of the log length where diameters are evaluated (only 2D measurement is compared). However, values measured in mm are converted to cm in such a way that they do not take into consideration mm, namely both at particular measurements (often) and at calculated mean values of diameter in particular places of measurement (always). The mid diameter is determined as a mean or smaller value from two places of measurement. Between them, the centre of the nominal log length is situated. Thus, basic differences originate. A method of the volume calculation (Huber method) is identical in all currently used methods. Thus, differences resulting from the different determination of mid diameters of logs occur also in differences of determined volumes.

Volumes of logs evaluated by methods used at present at the electronic reception of logs are compared with results of a method, which determines the volume of logs by sections, the length of which corresponds to the density of evaluated measurements and values of diameters remain in mm. Thus, it represents the highest achievable approach the geometrical volume of logs from measured values. All compared methods used in practice at the electronic reception of logs show lower values of volume as compared with actual geometrical dimensions of logs (on average by 5 to 9%). These values (all) are lower than those shown by manual methods based on the measurement of mid diameter on one place (on average by 3 to 7%). More accurate evaluation of the volume of logs (e.g. using the method by sections) has not been found in practice although technical devices make possible to realize it both as for the number and accuracy of taken data and capacity of these devices.

Results achieved are only based on 2D measurements, i.e. perpendicular at each other and predetermined directions. They do not include differences resulting from searching the smallest values of diameters at using 3D sensors.

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