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The Impact of Harvester Calibration on the Accuracy of Birch Veneer Logs Measurements by Measuring Diameter in Short Intervals Using Electronic 3d Systems

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Abstract. Accurate calibration of the harvester head relies on accurate manual log measurements. According to the recommended calibration procedures as proposed by the harvester manufacturer the differences between the volume measurements from harvester measurement system and the caliper-and-tape system must be within ± 3% and harvester diameter measurements within ± 6mm of manual measurements in 80% cases.

Requirements in Latvia stipulate that total volume measurement accuracy levels must be within ± 5% of actual volume if veneer or birch logs are being harvested, ± 3% if saw logs are being harvested and ± 10% if pulp wood or fire wood are being harvested.

The purpose of this study is to assess the impact of harvester calibration on the accuracy of birch veneer logs measurements by Measuring Diameter in Short Intervals using electronic 3D systems when different double bark volume determination algorithm are used in harvester and stacionar measurement system. The research was carried out in December 2016 in the region Latgale in Latvia. The wood felling area was chosen - Mercurialiosa mel. For volume estimation the sequent measurement equipment were applied: harvester Ponsse ERGO 8W, harvester information system Opti 4G and electronic 3D scanner system Elmes 3600.

The research is a continuation to the work done in the project „Harmonisation of piece-by-piece measurement methods of roundwood approved by Standard LVS 82:2003 „Apaļo kokmateriālu uzmērīšana" [6], the project "Harmonization of piece-by-piece measurement methods in all stages of roundwood manufacturing processes" [7] and the project "Investigation and evaluation of the methodology of determination of solid volume according to the stacked volume on roadside and in forwarder loads for logistics purposes in LATVIA" [8].

Keywords: Harvesters; calibration; measurement accuracy, veneer logs, volume.

I. INTRODUCTION

Sawmills orders for roundwood assortiments from the woods are being made by increasingly tight specifications. A log that has been harvested in a specified lenght and diameter in the wood felling place often ends up in a different diameter class at the sawmill. Thus the quantities of logs in the specified classes delivered to the mill often fail to meet the specification. The main reasons are sequental:

1. Harvester measuring system doesn`t work correctly.

In order to ensure that the harvester systems for measuring roundwood lenght, diameter are accurate, the harvester control and calibration procedures are applied making random control measurements of a number of stems and comparing the results with the machine data. In Latvian forest industry the methodology of harvester calibration is based on StanFord standard [10]. According to the standard, the analysis of harvester measuring system accuracy has been made using harvester calibration and control measurement Ktr-file.

An independent auditor monitors the results continually and visits every harvester a number of times a year to verify that the specified procedures are being followed.

In Finland data from these measurement systems are used as a basis for optimising machine yield and assortment mix, payment of contractors, payment of timber growers and the monitoring of operators [5].

What does it mean "well calibrated harvester measurement system"?

In Ireland volume accuracy levels of 6.7% for a clearfell site and 5.3% for a thinning site are determined [9].

Harvester calibration requirements in Latvia stipulate that volume estimates of control roundwood assortiments must be within ±3% of the true volume and at least 80% of all diameter measurements shouldn't exceed ±6mm deviation.

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2. Measurement requirements used by the harvesters differ from those used by the mills.

The analyses of roundwood measurement requirements used in harvester measuring systems [1;2;3; 4;11;12;13] are given (Table 1).

Table 1
The Measurement Requirements Used in Harvester Measuring Systems

VariablesB2:O55	Criteria	Countries									
		Swe $_{sub}$	Swe $_{to}$	Fin $_{sob}$	Nor $_{mid}$	Ger $_{mid}$	Ger $_{top}$	Dan $_{mid}$	Est $_{mid}$	Fra $_{sub}$	Latvia* $_{sub}$
Diameters in Diameter Classes (price matrix)	1=Top 2= Midpoint	1	1	1	1	2	1	2	1	1	1
Diameter Class Adjust	1=diameter class smaller or equal to log diameter 2=closest diameter class, normal rounding	1	1	1	1	1	1	1	1	1	1
Diameter Classes under bark	True/False	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
Position from top end of log where top diameter is measured	Cm	10	10	0	10	0	0	0	0	0	10
Lenght Class Adjust	1=lenght class smaller or equal to log diameter 2= closest lenght class, normal rounding	1	1	1	1	1	1	1	1	1	1
Diameters in log price volume calculation	1=measured diameter 2=measured diameter rounded down to cm	1	1	1	1	1	1	1	1	1	1
Diameters used in log price volume calculation	1=Solid volume 2=Top 3=Mid 4=Calculated Norwegian mid 5=Calculated Estonian mid	1	2	1	4	3	3	3	5	1	1
Lenghts used in price volume calculation	1=Physical lenght 2=Lenght as defined in Lenght Classes 3= Rounded dounwards to nearest dm-module 4=Rounded to nearest dm-module	1	2	1	3	2	2	1	1	1	2
Price volume under bark	True/False	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
Position from top end of log where top diameter for log volume calculation is measured	Cm	10	10	0	10	0	0	0	0	0	10
Bark Function Category	1=None 2=Swedish Zacco B=f(diam o.b.) 3=German B=f(diam o.b.) GermanDistanceBased B=f(dbh, h) 4=Skogforsk 2004, Scots pine B=f(dbh, h, lat) 5=Skogforsk 2004, Norway spruce B=f(dbh, diam o.b.) 6= Joint Stock company`s "Latvijas valsts meži "Apt-file, pine B=f(diam o.b.) 7= Joint Stock company`s "Latvijas valsts meži "Apt-file, spruce B=f(diam o.b.) 8= Joint Stock company`s "Latvijas valsts meži "Apt-file, birch B=f(diam o.b.) 9= Joint Stock company`s "Latvijas valsts meži "Apt-file, aspen B=f(diam o.b.)	2; 4 ; 5	2; 4 ; 5	1	2; 4 ; 5	3	3	1	2; 4 ; 5	2; 4 ; 5	0 ; 6 ; 7 ; 8; 9

3. Diameter (under bark) measuring technique used in the mills is not the same as that used by the harvesters.

Inspite of calibration of the harvester measuring system using individual logs is very accurate, the volume meaurement results are unsatisfactory when comparing the volume calculation results obtained in harvester and stacionar measurement equipment in sawmill. The differences between the harvester measurements and the stacionar measurement equipment measurements fluctuate, varrying from positive to negative volume values. These differences could be explained with the methodical procedure based on different and variet criteria.

One of the criteria is bark thickness estimation methodology. Harvester measurement system calculate double bark thickness from diameter over bark and use the results to estimate roundwood assortiment diameter and volume under bark (u.b.).

For birch logs and veneer logs the double bark thickness at the point of measuring is determined in Apt-file by using the sequential formula (1).

$$B=3,45+0,0404xD \quad (1)$$

where: D – diameter of roundwood assortiment over bark (o.b.), mm.

In veneer mill each veneer log is appreciated according to bark amount (%) and diameter (mm) coherence (Table 2.) and bark's presence on log surface. If the bark presence on log is less than 50%, the log is measured without bark.

The corresponding variables related to the investigation are defined below:

Apt-file Bucking(cross-cutting) instructions

DBH ($d_{1.2}$) The first measuring point done by harvester measuring system for butt diameter prediction

Ktr-file Harvester calibration and control measurement file. Sent from digital callipers to (on-board) merchandishing (bucking) computer, and from merchandishing computer to the office computer

Mercurialiosa mel. Woodlands on drained mineral

Prd-file Production of the harvester (measurement certificate)

Pri-file Production-individual. Data of each log made from the site

Table 2.
Bark Amount (%) and Diameter (mm) Coherence

Bark amount,%	Diameter min. (mm)	Diameter max. (mm)
12	0	190
11	190.1	230
10	230.1	390
9	390.1	999

II. MATERIALS AND METHODS

The wood felling area (Fig. 1.) was chosen - *Mercurialiosa mel.* The study was carried out in december 2016 in the region Latgale in Latvia. The wood falling time was chosen because of the minimal risk of debarking in the process of harvesting.

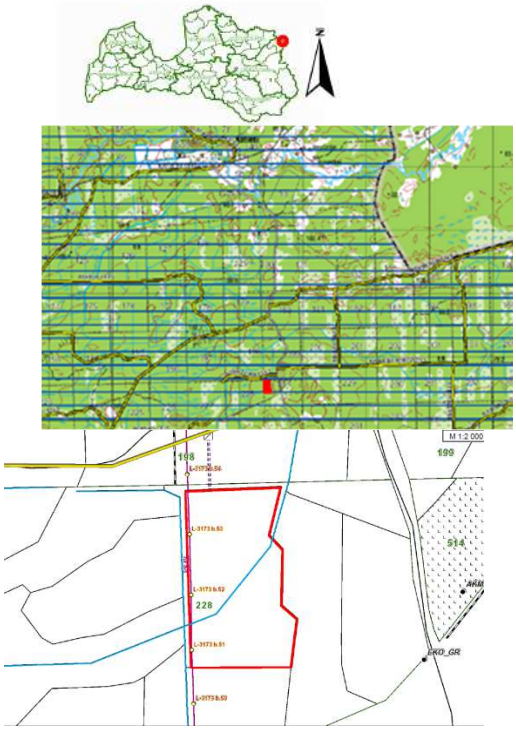

Fig. 1. Wood felling area and the technological scheme of harvesting, where species of a trees: 10% pine, 20% spruce, 70% birch

The following procedures were used to achieve the required objective:

To control the measurement accuracy of harvester Ponsse ERGO 8W measuring systems and electronic 3D scanner system Elmes 3600.

1. To identify the birtch stems before harvesting and all veneer logs after harvesting.To measure the identified veneer logs by measuring diameter in short intervals using electronic 3D systems.
2. To collect and analyse the harvester mesurement Pri-file data in connection with automatically measured parameters of veneer logs.
3. To analyse the measurement results.

The following measurement methods were applied in the investigation:

1. Individual measurement method by measuring diameter in short intervals using harvester measurement system.
2. Individual measurement method by measuring diameter in short intervals using electronic 3D system.

The following equipment were applied in the experimental investigation:

manual measuring equipment; harvester *Ponsse ERGO 8W*, harvester information system *Opti 4G* and electronic 3D scanner system *Elmes 3600*.

The object of the investigation were assortiments harvested according to the specification (Table 3.).

Table 3
Specification of Birch Veneer Logs

Assortiment, mm	Identification of the top diameter, mm	Top diameter (min/max), mm	Nominal lenght, m	Max. diameter, mm
120x139	120-139	130/139	4.8	700
140x159	140-159	140/159	4.8	700
160x179	160-179	160/179	4.8	700
180x209	180-209	180/209	4.8	700
210x249	210-249	210/249	4.8	700
250-299	250-299	250/299	4.8	700
300-399	300-399	300/399	4.8	700
400<	400	400/700	4.8	700

III. RESULTS AND DISCUSSION

Harvester measurement accuracy were assessed through comparison with manual log measurements and volume calculation according to the schemes (Fig.2.,3.,4.)

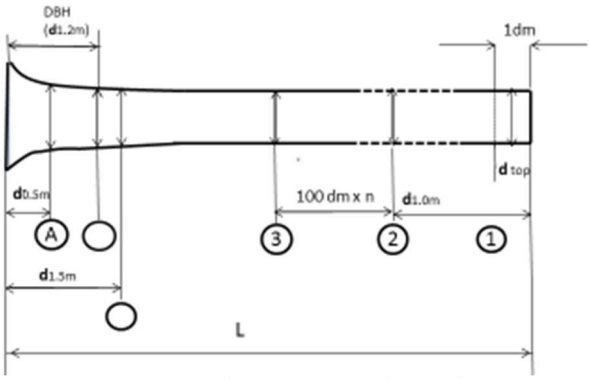

Fig. 2. The scheme of measuring points for logs from neiloid zone of stem in the process of harvester Ponsse ERGO 8W measurement system controlling, where:

DBH ($_{d1.2m}$)- the first measuring point done by harvester measuring system for butt diameter prediction; A - the last manual control measuring point (A=50 dm)

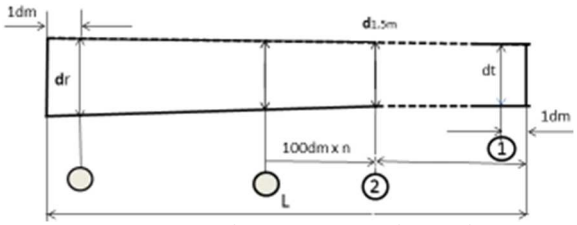

Fig. 3. The scheme of measuring points for logs from paraboloid zone of stem in the process of harvester Ponsse ERGO 8W measurement system controlling

Fig. 4. The control of the harveaster Ponsse ERGO 8W measuring system by independent auditor**,** where:

volume of the control assortiments measured by harvester measurement system 5.430m^3; volume of the control assortiments measured by caliper 5.426m^3; volume deviation 0.1%; 49% of all diameter include in ±2mm deviation; 79% of all diameter include in ±4mm deviation; 93% of all diameter include in ±6mm deviation

All veneer logs were identified in the process of harvesting (Fig.5.), collected in the load (Fig.6.) and measured by measuring diameter in short intervals using electronic 3D systems (Fig.7).

Fig. 5. The example of identified veneer logs N^o 22; 23; 24

Fig. 6. The load of identified veneer logs

Fig. 7. The example of measuring process and measurement results of identified veneer log N^o 24 using 3D scanner systemElmes 3600, where: actual lenght (cm) 493; nominal lenght (cm) 480; top diam.u.b.(mm) 232.9; actual volume u.b.(m^3) 0.236; nominal volume u.b.(m^3) 0.230

All harvester measurement results were collected using Pri-file data (Fig.8.) and analyzed (Table 3) in connection with automatically measured parameters of veneer logs.

The measurement results of the investigation are given (Table 4.)

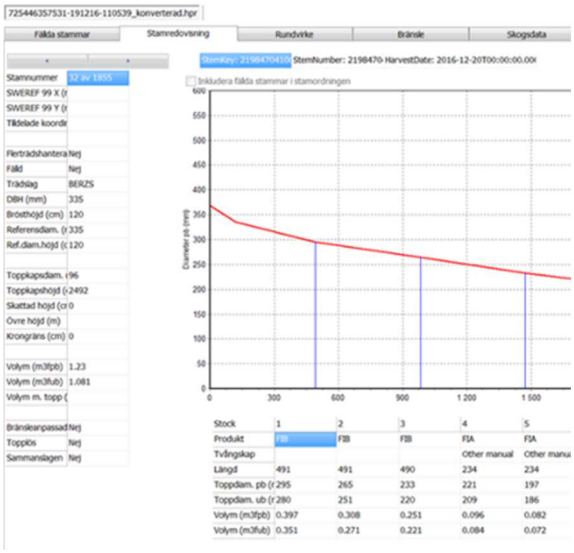

Fig. 8. The example of the measurement results of the stem and identified veneer logs Nr.22; 23; 24 in Pri- file, where:

birch stem DBH (mm) 335; birch stem volume (m^3 fub) 1.081; veneer log Nr.22 - lenght 491(cm); top diam.u.b.(mm) 280; volume u.b.(m^3) 0.351; veneer log Nr.23- lenght 491(cm); top diam.u.b.(mm) 251; volume u.b.(m^3) 0.271; eneer log Nr.24- lenght 490(cm); top diam.u.b.(mm) 209; volume u.b.(m^3) 0.221

Table 4.
The Measurement Results

Variable	**Measurements**
Number of veneer logs	50
Amount of butt assortiments, %	36
Neto volume by harvester, m^3(u.b.)	13.397
Actual volume by 3D scanner, m^3(u.b.)	13.819
Neto volume by 3D scanner, m^3(u.b.)	13.484
DBH (1.2m), mm	
Average	309.8
Median	316.5
Lenght, cm	
Average	491
Median	491
Standard deviation	2.08
Standard error	0.29
Diameter, mm	
Average	245.3
Median	246.5
Standard deviation	6.1
Standard error	0.86
Volume, m^3	
Average	0.267
Median	0.253
Standard deviation, %	3.6
Standard error, %	0.5

IV. CUNCLUSION

1. No clear effect of calibration can be detected on diameter measurements due to different approach of double bark thickness calculculation. Diameter standard deviation reaches 6.1mm if the harvester measuring system calculates diameters (u.b.) using double bark function (1), but electronic 3D scanner system uses bark amount (%) and diameter (mm) coherence (Table 2).
2. Standard deviation reaches 3.6% if volume of veneer logs (u.b.) are calculated using different double bark calculation methods.
3. Standard deviation reaches 2.08 cm in lenght measurements.

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