THE ANALYSIS OF CONIFEROUS LOGS TOP DIAMETER MEASUREMENT ACCURACY UNDER BARK USING HARVESTER AND 3D SYSTEMS

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Plan of the presentation

- Topicality
- Research methodology
- Research results and conclusions

The topicality of the theme

Serious **deviations** between diameter and length parameter measurements appears when the same roundwood assortments are measured by **harvester** and **3D measurement system**.The main part of sawlogs harvested according to the pricelist in sawmills are measured in different diameter groups.

Therefore

coniferous logs harvested according to the harvesting task requirements regarding to the top diameters have to be rejected or reducted in lenght in case if the parameters measured in sawmills using 3D systems won`t correspond to the specification.

The goal of the investigation

The goal of this study was to evaluate the impact of the **harvester calibration** on the **accuracy** of coniferous logs **top diameter measurements** by taking into account sources of errors specific to the harvester measurement system

Main tasks (1)

- To check the **measurement accuracy** of harvester John Deer 1470D ECO111 measuring system (harvester head: HD 758; measuring equipment: TimbermaticH 300; caliper version: SKALMAN 5.16) and electronic 3D scanner Microtec;

- to evaluate the **bark type** in the process of roundwood measuring in sawmill;

- to investigate the **bark thickness** impact on roundwood volume estimates;

Main tasks (2)

- to check and evaluate the **measurement accuracy of harvester measuring system** by collecting and analyzing the measurement data of each log processed on site (Pri-file) in relation to the measuring results of the identified logs in sawmill by measuring diameter in short intervals using 3D systems;

- to collect and analyse the harvester measurement **(Pri-file)** data in connection with automatically measured parameters of all coniferous logs harvested according to the specifications

  and

- to analyze the measurement results

Methods applied (1)

- Individual measurement method by measuring diameter in short intervals using harvester measurement system
- Individual measurement method by measuring diameter in short intervals using electronic 3D system

Equipment applied

- Manual measuring equipment
- Harvester (John Deer 1470D ECO111)
- Harvester head (HD 758)
- Measuring equipment (TimbermaticH 300; caliper version SKALMAN 5.16)
- Automatical measuring system (3D scanner Microtec)

Measurement accuracy

The harvester measuring system was checked by an independent auditor and the results were as follows:
53% of all **diameter** measurements were included in **±2mm** deviation; **82%** of all diameter measurements were included in **±4mm** deviation; **96%** of all diameter measurements were included in **±6mm** deviation.

Measurement accuracy

The control results of 3D scanner Microtec

Etalon Nr.	**VW1182**	**VW1183**	**510173050**	**510174050**	
Etalon lenght, mm	3046	4962			
Etalon diameter, mm			140.5	240.1	
Average, mm	3044	4964	140.6	240.4	**Accepted, mm**
Standard deviation, mm	2.5	2.9			±10
Standard deviation, mm			0.5	0.6	±1
Maximal positive, mm	0.3	0.7	0.5	0.6	2
Maximal negative, mm	0.8	0.2	0.4	-0.1	-2

A specification of roundwood assortments

Species	Diameter group, mm	Nominal lenght, m
Scots pine	0-100	4.2, 4.8
	100-140	3.6
	140-180	3, 3.6, 4.8
	180-280	3, 3.6, 4.8
	280-419	3.6, 4.8
Norway spruce	0-100	3.0, 3.6, 4.8
	100-140	3.6
	140-180	3, 3.6, 4.8, 6.0
	180-280	3, 3.6, 4.8, 6.0
	280-419	4.2, 4.8

Wood felling area and the technological scheme of harvesting

Myrtillosa mel.

60% spruce, 10% pine, 10% birch, 10% black alder

The identified stems

The identified logs

The identified logs

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The identified logs

Roundwood assortments

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Roundwood assortments

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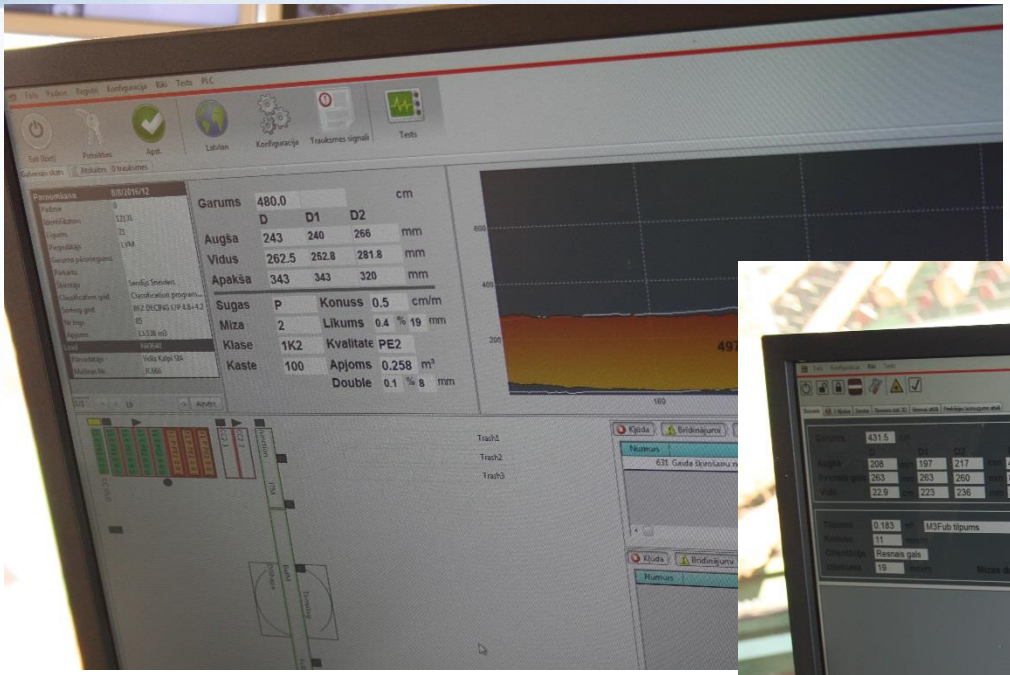
Evaluation of the bark type

Specie	***Scots pine***			
Bark type	Without bark	Thin bark	Middle bark	Thick bark
Thin bark, %	0	60<		
Middle bark, %	0	30<	90<	
Thick bark, %	0	30<	60<	90<
Specie	***Norway spruce***			
Bark type	Without bark		Middle bark	
Middle bark, %	0		60<	

Evaluation of the bark type

The measurement process



Evaluation of the bark type and measurement parameters

*An example of bark evaluation according to the **bark presence** on log Nr 5. surface*

The actual top diameter o.b-305mm

Double bark thickness **Bb-20mm (thick)**

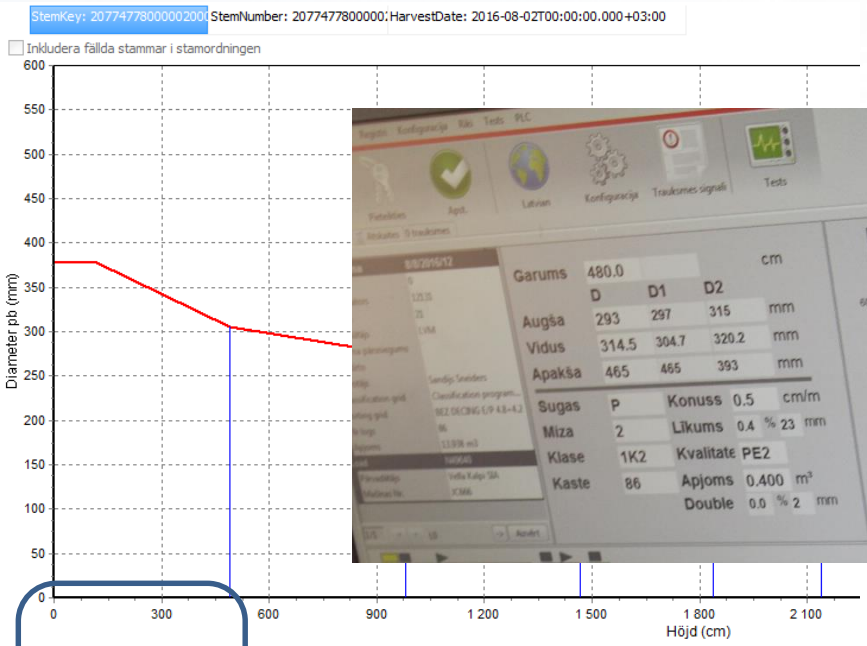
Double bark thickness **Bv,** measured by harvester measuring system -**12mm (middle)**

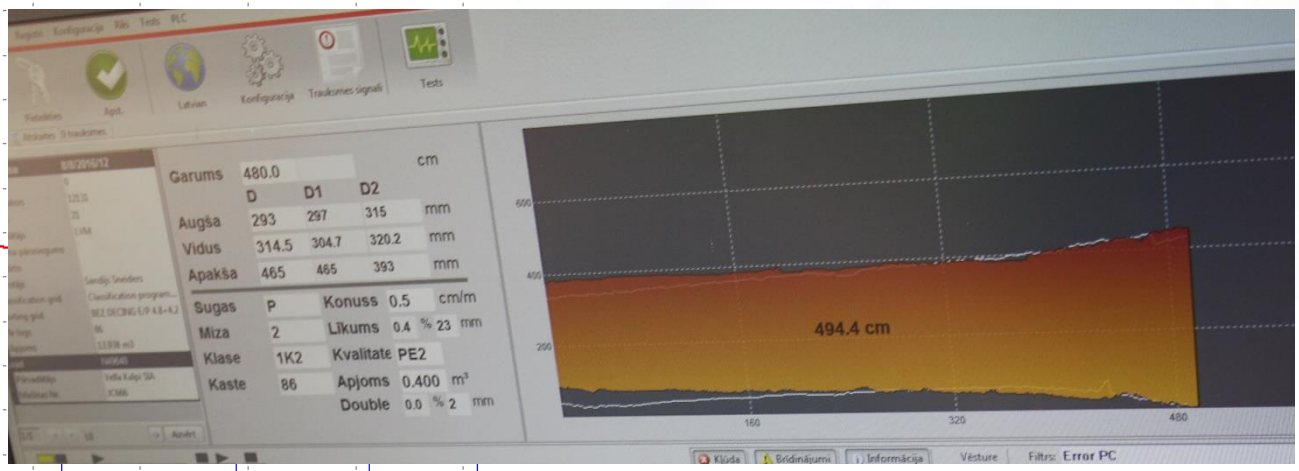
Bark presence on log surface 60-90%

Double bark thickness **Bv**, measured by 3D measuring system - **12mm (middle)**

Evaluation of the bark type and measurement parameters

Stamnummer	2 av 562
SWEREF 99 X (m)	
SWEREF 99 Y (m)	
Tilldelade koordinater	
Flerträdshanterad	Nej
Fälld	Nej
Trädslag	PRIEDE
DBH (mm)	378
Brösthöjd (cm)	1
Referensdiam. (mm)	378
Ref.diam.höjd (cm)	120
Toppkapsdiam. (mm)	97
Toppkapshöjd (cm)	2140
Skattad höjd (cm)	0
Övre höjd (m)	
Krongräns (cm)	0
Volym (m3fpb)	1.112
Volym (m3fub)	1.02
Volym m. topp (m3fu	
Bränsleanpassad	Nej
Topplös	Nej
Sammanslagen	Nej





Stock	1	2	3	4	5
Produkt	18X28	18X28	18X28	14X18	PMTK
Tvångskap					Other manual
Längd	489	490	489	369	303
Toppdiam. pb (mm)	305	273	222	168	97
Toppdiam. ub (mm)	292	261	212	160	92
Volym (m3fpb)	0.418	0.317	0.229	0.105	0.043
Volym (m3fub)	0.385	0.291	0.21	0.096	0.038

Log Nr. 5

The measurement results of identified assortments

Number of Scots pine stems	7
Number of logs	24
Number of butt assortiments	7
Neto volume by harvester, m^3 (u.b.)	4.6
Neto volume by 3D scanner, m^3 (u.b.)	4.71
DBH (1.3m), mm	
Average	257
Median	261
Double bark thickness, mm	
Average	7.7
Median	6
Standard deviation	2.1
Standard error	1.4
Actual lenght, cm	
Average	452
Median	492
Standard deviation	2.2
Standard error	0.4
Diameter, mm (o.b.)	
Average	245.3
Median	246.5
Standard deviation	6.5
Standard error	1.2
Diameter, mm (u.b.)	
Average	219.4
Median	222
Standard deviation	6.4
Standard error	1.2
Volume, m^3 (u.b.)	
Average	0.196
Median	0.2
Standard deviation,%	3.36
Standard error,%	0.64

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The deviation of measured diameter groups

Species	Diameter group, mm	Nominal lenght, m	3D measurement results, m^3/pcs	Harvester measurement results, m^3/pcs	Harvested diameter groups, %	Deviation, %
Scots pine	0-100	4.2; 4.8	0.46 / 11		0	0.457
	100-139	3.6	0.07 / 1		0	0.07
	140-180	3; 3.6; 4.8	5.17 / 58	7.43 / 86	18.82	-2.265
	180-280	3; 3.6; 4.2; 4.8; 6	30.91 / 148	30.66 / 144	77.67	0.245
	280-419	3.6; 4.8	3.061 / 8	1.38 / 3	3.51	1.681
Norway spruce	0-100	3; 3.6; 4.8	0.377 / 6		0	0.377
	100-140	3.6	0.219 / 3		0	0.219
	140-180	3; 3.6; 4.8; 6	12.66 / 137	14.1 / 152	24.34	-1.441
	180-280	3; 3.6; 4.2; 4.8; 6	36.07 / 194	33.67 / 178	58.2	2.399
	280-419	3; 3.6; 4.8	9.23 / 26	10.12 / 29	17.46	-0.893
Total amount, m^3/pcs			98.21 / 592	97.36 / 592		

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Conclusions

- For the calibrated harvester measuring system, the control results which pointed out that **53%** of all *measured diameters* were included in the **±2mm** deviation; **82%** of all *measured diameters* were included in the **±4mm** deviation; **96%** of all *measured diameters* were included in the **±6mm** deviation, were in line with the determined measurement accuracy.

- **Standard deviations** reached **6.5 mm** *in diameter* (o.b.) measurements when the maximum level of 7mm was determined, **2.2cm** *in length* measurements when the maximum level of 3cm was determined and **2.1mm** *in double bark thickness* measurements when the 2.4mm was proposed [6].

- The measurement conformity of **Norway spruce**
  in *diameter group* of **140-180mm** reached **98.53%** in
  in *diameter group* of **180-280mm** reached **102.44%,**
  in *diameter group* of **280-419mm** reached **99.09%**

Conclusions

- The measurement conformity of **Scots pine**
  in the *diameter group* of **140-180mm** reached **97.69%**
  in the *diameter group* of **180-280mm** reached **100.25%**,
  in the *diameter group* of **280-419mm** reached **101.71%**

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