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Density of bio fuel – of energy chips from dendromass of Populus plantation-grown coppice

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Abstract: *Density of bio fuel – of energy chips from dendromass of Populus plantation-grown coppice.* This article presents the results of works which determine density of chips, juvenile wood and juvenile bark in a dry condition on the basis of dendromass of fast growing wood species grown on plantations Populus trees at the end of 5 year growing cycle. The work also contains data reflecting bulk density of chips from analysed wood species made on a chopping machine JUNKKARI HL 10, at relative humidity of poplars at harvest.

Keywords: bulk density, dendromass, chips, bio fuel, Populus

INTRODUCTION

In the last three decades, in order to increase the production of wood biomass for energy purposes, there was established number of plantations of short rotation coppices, with a production of wood biomass reaching at least 10 t per 1 ha per year. According to the research papers by: ***Varga and Godó*** (***2002***), ***Jandačka et al.*** (***2007***), ***Malaťák and Vaculík*** (***2008***), ***Liebhart*** (***2010***), ***Otepla and Habán*** (***2011***) the most suitable short rotation coppices grown on plantations for energy purposes in Central Europe are Robinia pseudoacacia L., various clones of Populus, Salix alba L. and various Salix viminalis clones.

According to the method of the plantations founding and the growing period of trees, plantations of fast-growing trees are divided to plantations with collection time under 5 years (mini rotation), from 5 to 10 years (midi rotation) and from 10 to 20 years (maxi rotation), ***Simanov*** (***1995***). The goal of dendromass production on plantations with collection time of 10 to 20 years is the production of fibre for cellulose and paper industry, feedstock for chipboards and branches for chips for energy sector.

The document presents results of experimental works which set a density of juvenile wood, density of juvenile bark and energy chips made from dry wicker from plantation grown clones Max 4, Max 5, Oxford, AF 2, Monviso fast growing wood Populus trees at the end of 5 year growing cycle and bulk density of energy chips with humidity during collecting.

MATERIAL AND METHODS

Samples of energy chips were collected at 5-year mining plantation grown trees stand Populus clones Max 4, Max 5, Oxford, from research station Kunovice and AF 2, Monviso from Alesie Franco of village Marchegg. The collection was realized during winter with a mower Finnish mobile manufacturing type: JUNKKARI HJ 10.

The density of juvenile wood, juvenile bark and energy chips produced from wicker of plantation grown Populus in dry conditions was set according to STN 49 0108.

Wood - Density detecting. Density of juvenile wood, juvenile bark as well as of the chip mass was calculated – out of measured weight values of a sample and sample volume – according to the formula:

$$\rho_0 = \frac{m_0}{V_0} \quad \left[kg.m^{-3}\right] \qquad (1)$$

Where:

m_0 – weight of dry sample [kg],
V_0 – volume of dry sample [m^3].

Relative humidity of energy chips was set according STN EN 14774 – 2 Solid bio fuel. – Determination of humidity capacity. Values of relative humidity of individual samples were calculated using following formula:

$$W^r = \frac{m_w - m_0}{m_w}.100 \qquad [\%] \qquad (2)$$

Where:

m_w – sample weight before exsiccation [g].
m_0 – sample weight after exsiccation to a constant weight [g].

The share of bark in green wood chips of individual Populus clones was determined in a laboratory, according to the norm STN 48 0058:2004 Assortments of wood. Chips and sawdust of hardwood. The share of bark in the sample was calculated using the formula:

$$X_B = \frac{m_B}{m_{Ch}}.100 \qquad [\%] \qquad (3)$$

Where:

m_B – weight of bark in the chips sample [g],
m_{Ch} – weight of the chips sample [g].

Bulk density of energy chips of Populus wood clones Max 4, Max 5, Oxford with humidity during collection time was set laboratory at the Technical University in Zvolen, Department of Woodworking, in terms of STN EN 15103:2010. The calculation of the bulk density with volume compression of the sample which is in a measure bin after multiple shaking of energy chips is described by a formula:

$$BD_{ar} = \frac{m_2 - m_1}{V} \quad [kg.m^{-3}] \qquad (4)$$

Where:

m_2 – weight of a measure bin filled with joggled bio fuel [kg],
m_1 – weight of an empty measure bin [kg],
V – volume of a measure bin [m^3].

RESEARCH RESULTS

Results of laboratory works setting a density of chips ρ_{0Ch} (wood and bark mixture), density of juvenile wood ρ_{0JW}, density of juvenile bark ρ_{0JB} and in dry conditions, middle values of relative humidity, share of bark and bulk density of Populus individual clones, are shown in a table 1, 2, 3, 4, 5.

Tab. 1 Basic statistical characteristics of density of juvenile wood of analysed clones plants Populus in a dry condition

Clone of wood species		Basic statistical characteristics			
		ρ_{0JW} [kg·m^{-3}]	s [kg·m^{-3}]	v_x [%]	n [-]
Populus	Max 4	408,5	16,3	3,9	16
	Max 5	400,3	11,9	2,9	15
	Oxford	425,6	10,4	2,4	18
	AF 2	436,8	13,1	3,0	16
	Monviso	406,9	11,1	2,7	15
	The average value	415,6	12,5	2,9	80

Tab. 2 Basic statistical characteristics of density of juvenile bark of analysed Populus clones plants in a dry condition

Clone of wood species		Basic statistical characteristics			
		ρ_{0JB} [kg·m^{-3}]	s [kg·m^{-3}]	v_x [%]	n [-]
Populus	Max 4	578,2	49,6	8,5	16
	Max 5	583,4	61,3	10,5	15
	Oxford	590,2	57,9	9,8	16
	AF 2	541,3	23,8	4,4	16
	Monviso	585,4	22,5	3,8	15
	The average value	575,7	43,1	7,5	78

Tab. 3 Basic statistical characteristics of density of chips (wood with bark) of analysed Populus clones plants in a dry condition

Clone of wood species		Basic statistical characteristics			
		ρ_{0Ch} [kg·m^{-3}]	s [kg·m^{-3}]	v_x [%]	n [-]
Populus	Max 4	438,1	17,8	4,1	16
	Max 5	456,7	24,8	5,4	15
	Oxford	458,3	21,3	4,6	16
	AF 2	421,4	27,1	6,4	16
	Monviso	441,5	19,8	4,3	15
	The average value	443,2	22,1	4,9	78

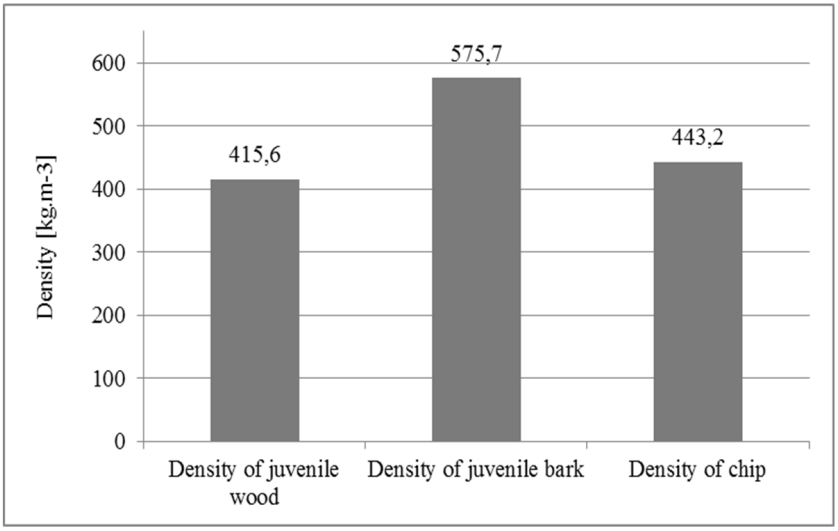

Fig. 1 The average value of density Populus clones in dry condition

Tab. 4 The average values of the share of bark and Relative humidity of juvenile wood and bark during the dormancy on a wood from plantation fast growing species

Wood	Share of bark [%]	Relative humidity [%]	
		Juvenile wood	Juvenile bark
Max 4	22,72	51,3	53,4
Max 5	21,33	52,6	54,4
Oxford	26,67	50,1	53
AF 2	21,63	54,3	53,1
Monviso	20,97	47,8	57,3
Populus	22,66 ± 2,69	51,2 ± 2,4	54,2 ± 1,1

The average values of the share of bark written as median and standard deviation

Tab. 5 Bulk density of chips of analysed clones of Populus the moisture at the time of harvest

Wood	Bulk density [kg·m^{-3}]
Max 4	300
Max 5	305
Oxford	320
AF 2	280
Monviso	300
Populus	301±17,5

The average values of the share of bark written as median and standard deviation

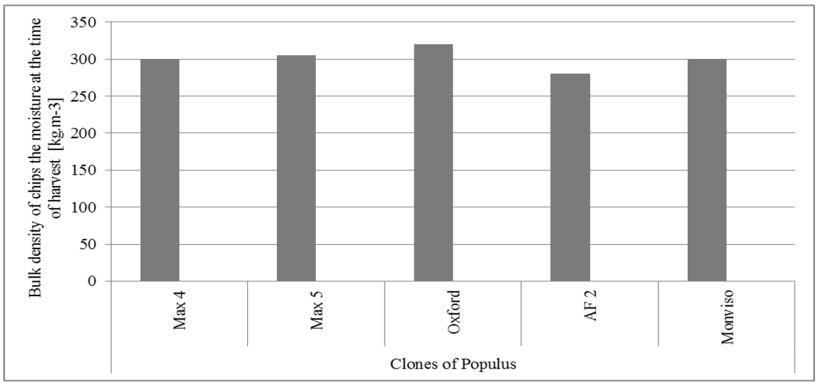

Fig. 2 Bulk density of chips of analysed clones of Populus clones the moisture at the time of harvest

DISCUSSION AND CONCLUSIONS

Average values of density of juvenile wood in dry condition of analysed Populus clones ρ_{0JW} = 415,6 kg·m^{-3} is comparable to a density of Poplar wood of a plantation grown Populus deltoides clone presented by the authors ***Klasnja – Kopitovic – Orlovic*** (***2002***) and is 15% higher than a density of a dry Poplar wood - Populus serotina as was mentioned in a work by ***Požgaj et al.*** (**1997**).

When comparing a density of dry juvenile bark with a density of dry juvenile wood of analysed clones, it is obvious that bark densities are higher than the woods densities. Dry poplar bark of analysed clones with a density ρ_{0JB} = 575,7 kg·m^{-3} comparing to dry wood density ρ_{0JW} = 415,6 kg·m^{-3} is higher by 27,8 %. Mentioned statements concerning the higher bark density correspond with the knowledge of a bark morphology as well as its chemical composition and a share of inorganic substances in the bark presented in literature ***Matovič*** (***1977***), ***Požgaj et al.*** (***1997***), ***Pelerygin*** (***1965***), ***Dzurenda – Zoliak*** (***2012***).

The bark share X_B = 22,66 ± 2,69% on the wood chips affects chips weight in dry and wet condition, and it also affects a bulk density as well as energetic characteristics such as heat of combustion, calorific value, ash content. The bark share in poplar chips is 6 to 7 % higher than the bark share e.g. in willow chips of clones Salix viminalis which are mentioned in works by authors ***Dzurenda, L. – Ridzik, L. – Dzurenda, M.*** (***2013***). A bark share in poplar chips from plantation-grown coppice in the interval X_K = 18,8 – 27,2 % is presented by the authors ***Varga - Godo*** (**2002**), *Dzurenda – Zoliak* (***2012***). Values of bark share of wood dendromass grown on plantations with collection time 5 years are 1,5 to 2,5x higher than a bark share on broadleaved tree trunk during its mature age. This statement is supported by the knowledge of dependence of a bark share on the tree diameter ***Požgaj et al.,*** (***1997***), as well as the knowledge of dependence of a bark share in a dendromass on the tree ***age Golovkov et al.,*** (***1987***), ***Varga - Bartko*** (***2010***).

Bulk density of chips made from a plantation-grown coppice dendromass of analysed fast growing clones by a mower JUNKKARI HJ 10 at humidity $W^r \approx 52$ % during dormancy was laboratory set for poplars as BD_{ar}= 301 kg·m^{-3} . Presented weight data l of cubical m^3 of energy chips are important for planners in the design of warehouse for bio fuel storage, as well as for carriers of biofuels from plantations to stock ***Jandačka et al.*** (***2007***), ***Malaťák and Vaculík*** (***2008***), ***Dzurenda M.*** (***2014***).

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Streszczenie: *Gęstość biopaliwa – zrębków energetycznych z plantacji dendromasy topoli -wyrośnięte odrośla*. W artykule przedstawiono wyniki prac, które określają gęstość zrębków, drewna młodocianego i kory w stanie suchym pozyskanych z szybko rosnących gatunków

plantacyjnego drewna topolowego w końcu 5 letniego cyklu wegetacyjnego. Praca zawiera także dane o gęstości objętościowej zrębków analizowanych gatunków drewna wykonanych na rębarce JUNKKARI HL 10, przy wilgotności względnej topoli podczas pozyskania.

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