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INFLUENCE OF SELECTED MATERIAL AND PROCESS PARAMETERS ON THE DURABILITY OF BRIQUETTES FROM SHREDDED LOGGING RESIDUES

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The aim

The aim of the research was to determine the elemental composition and energy properties of the tested raw material, the possibility of using shredded material for briquette production, as well as determining the most favorable, from the point of view of briquette durability, the fractional composition of the compacted biomass and process parameters.

Materials and Methods

The research material consisted of logging residues obtained in the process of harvesting wood in an 80-year-old pine stand (*Pinus Silvestris* L.), crushed with a hammer shredder into chips with dimensions not exceeding 16 mm. The chips with a moisture content of 10, 15, 20% were compacted in a closed chamber at unit pressures of about 65 MPa at a temperature of 22 and 73^{o}C.

Figure 1. Logging residues: a) not shredded, b) shredded

The influence of the fractional composition of the briquetted mixture, its moisture content and the temperature of the compaction process on the durability of the product was made for the wood chips prepared by mixing the separated size fractions in various proportions.

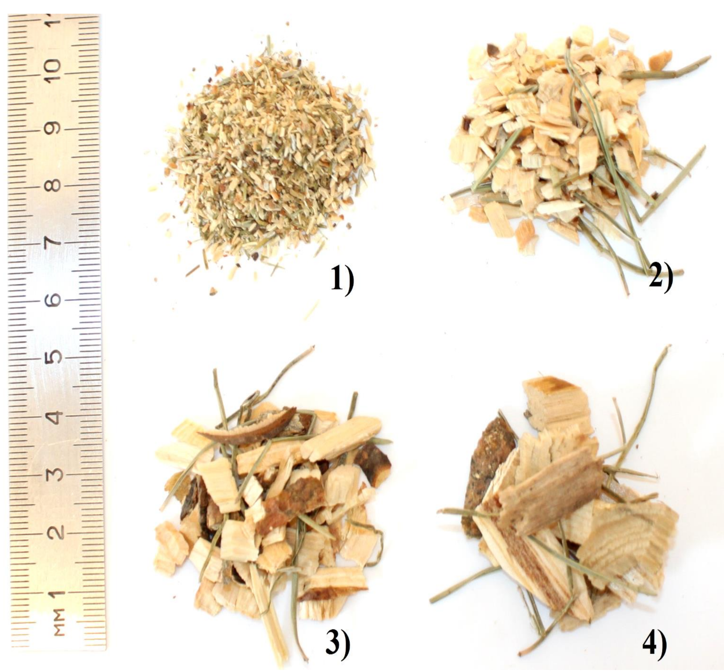

Figure 2. Fractions of selected wood chips 1) 0-1 mm, 2) 1-4 mm, 3) 4-8 mm, 4) 8-16 mm

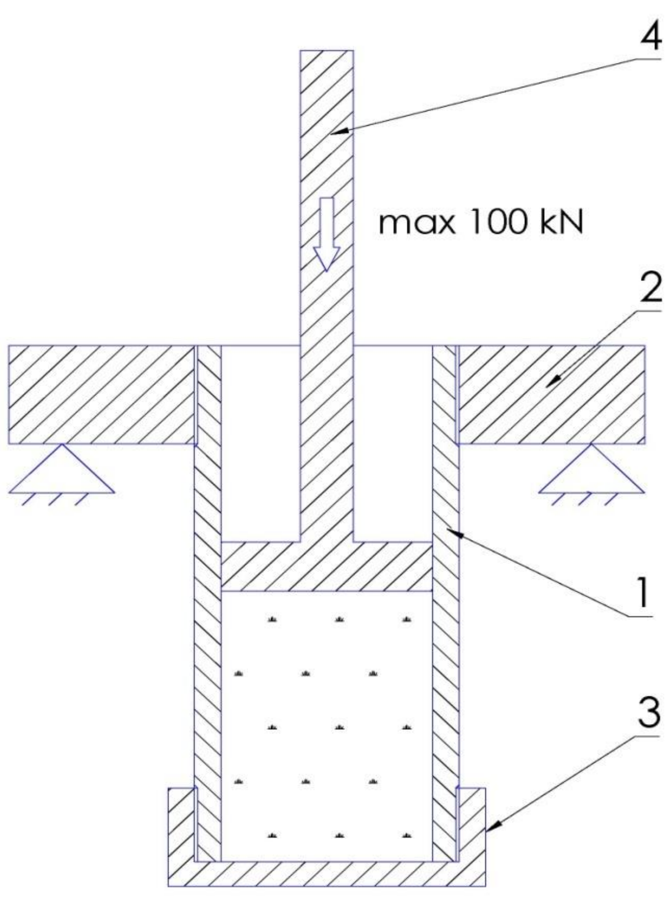

Figure 3. Schematic diagram of agglomeration stand (compaction die); 1 – compaction die, 2 – support, 3 – bottom, 4 – piston [7].

Figure 4. Samples of obtained briquettes

The analysis of the carbon, hydrogen, nitrogen and sulfur contents (CHNS) was performed using the Elementar Vario Macro apparatus according to the procedure described by Sadhukhan et al. Then the sample of raw material was incinerated, determining the ash and oxygen contents. The share of oxygen was determined on the basis of the content of other elements and ash in the analyzed material. The mechanical durability of briquettes was determined according to the EN-ISO 17831-2:2015 standard. The durability of briquettes was determined by dimensionless durability coefficient (Ψ) as a ratio of mass remained after the analysis on the screen to the total mass of analyzed briquettes.

Figure 5. Stand for briquettes durability determination

Results

Low content of nitrogen and sulfur (0.66 and 0.25%) and a significant share of carbon (over 50%) prove the possibilities of using pine logging residues as an energy raw material. Taking into account the low content of nitrogen and sulfur, low emission of harmful substances in the combustion process can be expected. The carbon content results in the calorific value of this biomass, encouraging further research.

Table 1. The share of elements and mineral compounds in the tested raw material and comparative materials.

	C	H	N	S	O	Ash
LR	50.84 (±0.07)	5.72 (±0.16)	0.66 (±0.06)	0.25 (±0.13)	41.46 (±0.07)	1.07 (±0.09
EC	49.95 (±0.08)	5.76 (±0.05)	0.27 (±0.02)	0.12 (±0.01)	41.99 (±0.05)	1.91 (±0.11)
WSC	48.42 (±0.08)	5.64 (±0.06)	0.41 (±0.02)	0.10 (±0.01)	43.01 (±0.03)	2.42 (±0.11)

where LR – Logging residues, EC – Energy chips, WSC – Wood saw chips

The research allowed to found that the highest, although unsatisfactory, values of the durability coefficient were obtained in the case of compaction of biomass with a moisture of 10% (Table 2). These studies also allowed to reject the temperature of 22^{o}C as too low to ensure the correct course of the process and the occurrence of the phenomena desired in the agglomeration process.

Table 2. Mean values of durability coefficient for briquettes made of material with 'natural- unmodified fractional composition'

Moisture content, %	Temperature, °C	Durability coefficient
10	22	16.5 (±3.2)
	73	22.4 (±2.6)
15	22	16.7 (±1.8)
	73	17.3 (±1.9)
20	22	8.4 (±2.7)

The results of the main series of tests (for the material with modified fractional composition) were presented in Table 3. Briquetting was carried out for two temperatures (73 and 103^{o}C and moisture equal to 10%. In all cases, the briquette's mechanical durability coefficient ranging from 42–72.5% was unsatisfactory and lower than 80–98% obtained for briquettes made of sawdust, crushed plants or crushed cones. In the discussed studies, the highest value of the durability coefficient was obtained for the mixture of: 50% of the fraction 0-1 mm, 25% of the fraction 1-4 mm, 25% of the fraction 4-8 mm, compacted at the temperature of 103^{o}C.

Table 3. Durability coefficient for varied fractional composition of biomass compacted in two temperatures 73 and 103^{o}C

Share of fraction, %				Temp, °C	Durability coeffcient
0-1 mm	1-4 mm	4-8 mm	8-16 mm		
50	25	25	0	73	68.1 ±6.2
				103	72.5 ±3.0
75	0	0	25	73	42.0 ±2.9
				103	67.4 ±5.2
75	0	25	0	73	64.2 ±5.9
				103	50.9 ±5.3
75	25	0	0	73	51.1 ±1.0
				103	66.1 ±2.7

Conclusions

- On the basis of the conducted research, it was found that the chemical composition of the tested biomass differs from the composition of other compared raw materials. However, it is advantageous for a raw material for the production of solid fuels.
- The most favorable, though unsatisfactory, value of the durability coefficient was obtained for the compaction of wood chips with a moisture content of 10% and a temperature of 103^{o}C.
- The fractional composition of the compacted biomass affects the value of the durability coefficient. The most favorable results among the tested mixtures were obtained for the composition: 50% of the 0–1 mm fraction, 25% of the 1-4 mm fraction, 25% of the 4-8 mm fraction.