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Address: Univerzitetski trg 2, 18000 Niš,YU, Tel. +381 18 547-095, Fax: +381 18 547-950
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USABILITY OF LIGHT COMPOSITIVE BIOBRIQUETTES

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Dragan Mitić

Occupational Safety Faculty, University of Niš

Abstract. *In literature there is a certain number of data about light briquettes, but they can not be treated as enough for bringing of general conclusions about possibilities of their usability. In this paper are presented results of experimental researchings on compositive biobriquettes which has been done in laboratory for combustion on Occupational Safety Faculty in Niš. Authors hope that this researchings will help to more particular studying of place and significance of compositive biobriquettes from economical, ecological and energetical aspect.*

Key words: *light compositive biobriquettes, possibilities of usability, economy, ecology and energy.*

1. INTRODUCTION

About possibilities of biomass usability, their disadvantages, characteristics which make them bad for larger application and poorly usefullness has already been written in a great deal in domestic literature [1,2,3,4]. Greater part of biomass disadvantage properties in basic, rinfuz state it is possible to exceed by production of biobriquettes [1,2,5]. Technic-technological possibilities of light biobriquettes production, on the other hand, offer new possibilities comparing to heavy briquettes and among certain disadvantages [1,6].

As criteria for evaluation of light compositive biobriquettes usabilities are defined:
- volume mass;
- bulk volume mass;
- storage characteristics;
- heat power;
- volume heat power;

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- results of fuel technical analysis;
- technic-technological production possibilities and
- economical indicators.

From collection of these criteria here are not treated only last two, because they demand some backgrounds which refer to calculation of product prices and production expenses which are not available to authors.

For calculation treatment of these indicators are used own experimental results:

- laboratory researchings of biomass properties of Serbia [1,2,3,5,6];
- laboratory researchings of light compositive biobriquettes physical properties [8,9, 10] and
- technical analysis of Serbia biomasses [1,5,7].

2. MATERIAL AND METHODS

Material and methods for examination of biomass physical properties and light compositive biobriquettes are descripted in details in [1,2,5,6]. Physical properties of biomasses, from which are made laboratory specimens for researchings of technic-technological biobriquettes production possibilities are examined in laboratories on Occupational Safety Faculty, Phyilosophical Faculty and Tobacco industry in Niš.

With respect to that, there is no normative methods which only refer to biomasses analysis, technical analysis of biomasses and paper are produced by normative methods from the group of Yugoslav standards for coal (JUS B. H8. 339, JUS B. H8. 312, JUS B. H8. 338, JUS B. H8. 318). Also are obtained technical analysis of biomasses with range of standard data, on which bases may be evaluate characteristics significant for use of light compositive biobriquettes.

Basic data about technical analysis of examined light compositive biobriquettes are, as for the other solid fuels, contents:

- raw and higroscope humidity (non-combustible evaporable materials);
- volatiles (combustible evaporable materials);
- ash (non-combustible non-evaporable materials, mineral materials) i
- coke residue (combustible and non-combustible non-evaporable materials).

Heat power is, also, stated as data from experimental researchings of biomasses. For technical reasons is not examinated behaviours of ash on higher temperatures, length and colour of flame, out-look and structure of coke residue etc. Overall results about examinations of biomasses technical analysis are shown in tables 1, 2 i 3.

3. RESULTS

Upper heat power of light compositive biobriquettes with structure which is defined in table 1. ranges from 15,84 to 18,9 MJ/kg commensurate to category of brown and brown-lignite coals. However, with respect to that volume mass of biomasses in rinfuz state extremely low-this criteria significantly displace their usability. So for grape vine cutting is 1012 MJ/m^3, huskus 2550 MJ/m^3, beech sawdust 2545 MJ/m^3, ash chippings 446 MJ/m^3 [1,3,5], which means that for biomasses used in examinated compositives ranges from 446 to 2545 MJ/m^3. Incorporation into light briquettes volume heat power is extensively ractify (table 1.) and ranges from 4990 to 8725 MJ/reduce to briquette or from 3900 to 7940 MJ/m^3/reduce to bulk briquette. From comparing of volume heat power of bulk light briquette and bulk biomass in rinfuz state, can be noticed that volume mass is ractifing from 2 to 10 times (graph 1.). Basic backgrounds and data for these interpretation are incorporated in table 2.

So, nevertheless about waste biomasses using, whose typical representatives here are incorporated in light briquettes, is obtaining fuel with representative characteristics about heat power and volume heat power too.

Table 1. Heat power and volume heat power of light compositive biobriquettes [7,8,9,10,11,12,13,14]

Ordinal	Structure	Volume mass range (kg/m^3)	Average volume mass (kg/m^3)	Upper heat power (MJ/kg)	Upper volume heat power (MJ/ m^3)	Upper volume heat power reduced to bulk volume mass (MJ/ m^3)
1	Paper	330-400	360	18,9	6800	4970
2	Paper-cuttings of grape vine	500	500	17,45	8725	7940
3	Paper-huskus of grape vine	470-540	500	18,25	9125	6700
4	Paper-rice shell	310-320	315	15,84	4990	3900
5	Paper-beech sawdust	360-390	380	17,28	6560	5200
6	Paper-nut shell	390-450	420	17,6	–	–
7	Paper-ash chipping	320-340	330	17,6	5800	4450

Table 2. Characteristic values of heat powers [1,8,11,14]

Ordinal	Structure	Upper heat power			Ratio*
		biomass (MJ/kg)	bulk volume of biomass (rinfuz) (MJ/m^3)	bulk volume of briquette (MJ/m^3)	
1	Paper-grape vine cutting	17,45	1012	7940	7,845
2	Paper-grape vine huskus	18,25	2550	6700	2,6
3	Paper-rice shell	15,84	1321	3900	2,952
4	Paper-beech sawdust	17,28	2545	5200	2,04
5	Paper-ash chipping	17,6	446	4450	9,977

* Ratio of volume heat power of bulk briquette and volume heat power of basic biomass

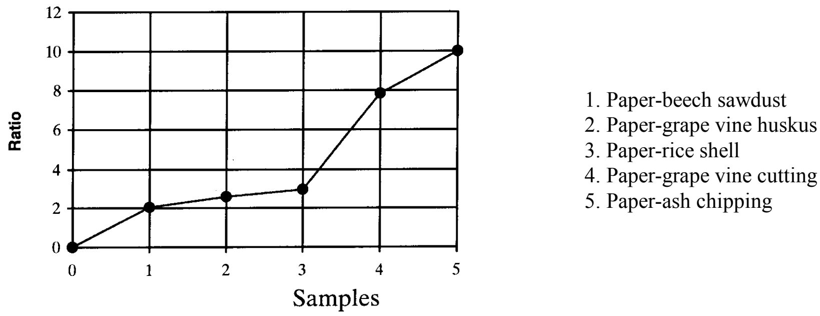

Diagram 1. Ratio of upper heat values of volume bulk briquette and volume bulk biomass

Results of technical analysis for light compositive biobriquettes are shown in table 3. It is possible to get following conclusions:

Ash

Ash content ranges from 7,7 to 11,08 %. The least ash content has light compositive biobriquette with grape vine cutting 7,7 %, and the largest light compositive biobriquette with grape vine huskus 11%. Comparing this ash content with ash content in brown-lignite coal "Soko" where it is 22,69 %, following conclusion is that this content is very low-even half less.

Content of fixed carbon

This data for examinated light compositive biobriquettes ranges from 9,6 to 14,5 %. Maximum value has light compositive biobriquette with grape vine cutting and minimum light compositive biobriquette made only of paper pulp. Together with ash content this content constitute coke residue.

Coke residue

It is very low (because of low contents of ash and fixed carbon) and ranges from 18,47 to 22,32 % (the least content of coke residue is at light biobriquette made of pure paper pulp 19,4 % and the largest is at compositive with grape vine huskus 31,35 %).

Moisture

Moisture content represent one of main disadvantages for larger use of biomass and at heavy briquette forming represent limit factor. At light biobriquettes forming humidity contents in biomass does not occur as limit factors. In table are shown only contents of higroscope humidity with an average content about 5,2 %.

Volatiles

In biomasses there is a high content of volatiles-from 70 to 80 % and at paper, too-76,5% [1]. Because of that there is extremely high volatile content in light compositive biobriquettes. For examinated specimens it ranges from 71 to 76 %.

Significant participation of combustible evaporable materials represent the most significant part of energy potential light compositive biobriquettes. From the other side it causes easily inflammability of biomasses and demands accurate construction of the furnice which will enable complete combustion of volatiles. This large content of volatiles may represent problem at inadequate projected furnices, esspecially there where does not exist enough height of firebox for complete combustion. Also, they may cause uneven temperature in firebox because of intensive separation and combustion in upper zones, aboutwhat has to be take care in projecting.

Combustible materials

In accordance with these results of biomasses technical analysis participation of combustible materials in light biobriquettes is vey significant-from 83,5 to 86,8 % (the greatest value is at vine grape cutting 86,3 %, while the least is at light biobriquette of pure paper pulp 81,72 %).

Table 3. Technical analysis of light briquettes examinated in laboratory for combustion on Occupational Safety Faculty in Niš [15]

Ordinal	Structure	$W_{H(a)}$ (%)	$A_{(a)}$ (%)	Vol_a (%)	$C_{fix(a)}$ (%)	Coke residue (%)	Combustible (%)	$H_{g(a)}$ (MJ/kg)
1	Paper	4,085	14,195	76,51	5,210	19,405	81,72	18,008
2	Paper-grape vine cutting	5,422	7,744	72,255	14,579	22,323	86,834	17,5
3	Paper-grape vine huskus	5,398	11,076	71,275	12,25	31,3495	83,525	18,28
4	Paper-beech sawdust	5,38	7,9415	73,605	13,073	21,015	86,678	17,283
5	Paper-ash chipping	5,174	8,911	76,355	9,559	18,470	85,914	17,616

Review of heat powers, volume heat powers and data about technical analysis for light briquettes, in whose compositive are taking part pulp/coal and hydrated lime as sorbent, is shown in tables 4 and 5. Results are sistemated for range Ca/S in fuel which ranges from 0 to 4. In spite to that upper heat power ranges from 17,8 to 18,9 MJ/kg, and volume heat power and bulk volume heat power are changing very little in function of molar ratio Ca/S-they depend more of material compression degree at briquetting. Ranges are from 7987 to 9316 MJ/kg and from 5291 to 5983 MJ/kg.

Table 4. Heat powers, volume heat powers and volume heat powers of bulk light briquettes paper/coal dust/hydrated lime [1,4]

Ordinal	Molar ratios Ca/S	Coal part / paper part	Average volume mass [kg/m^3]	Upper heat power (MJ/kg)	Upper volume heat power (MJ/m^3)	Upper volume heat power reduced to bulk volume mass (MJ/m^3)
1	0	0,5/0,5	453	17,81	8067	5645
2	1	0,487/0,5	510	17,58	8965	5379
3	2	0,474/0,5	537	17,35	9316	5291
4	3	0,462/0,5	466	17,14	7987	6941
5	4	0,451/0,5	477	16,95	8085	5983

Similar values of heat powers in the function of molar ratios Ca/S also obtain when as a sorbent is used limestone. Review of these data is given in table 5.

Table 5. Heat powers, volume heat powers and volume heat powers of bulk light riquettes paper/coal dust/ limestone[9]

Ordinal	Molar ratios Ca/S	Coal part / paper part	Average volume mass [kg/m^3]	Upper heat power (MJ/kg)	Upper volume heat power (MJ/m^3)	Upper volume heat power reduced to bulk volume mass (MJ/m^3)
1	0	0,5/0,5	453	17,81	8067	5645
2	1	0,477/0,5	530	17,41	9227	5431
3	2	0,456/0,5	445	17,04	7753	7122
4	3	0,437/0,5	477	16,70	7965	6479
5	4	0,419/0,5	468	16,38	7666	7125

Review of technical analysis for light compositive briquettes pulp/coal/hydrated lime and pulp/coal/limestone is given in tables 6 and 7. Union conclusion is that with growing of ratio Ca/S grows ash content (from 18,48 to 24,72 %), and coke residue (from 30,02 to 37,61 %). Volatile content calumniate very much from 57,28 to 53,42 %.

Table 6. Technical analysis of light comositive briquettes paper / coal dust / hydrated lime [16]

Ordinal	Molar ratio Ca/S	$W_{H(a)}$ (%)	$A_{(a)}$ (%)	Vol_a (%)	$C_{fix(a)}$ (%)	Coke residue (%)	Combustible (%)	$H_{g(a)}$ (MJ/kg)	$H_{d(a)}$ (MJ/kg)
1	0	9,38	18,48	57,28	14,88	33,36	72,16	17,817	
2	1	9,19	19,46	56,72	14,63	30,02	71,35	17,589	
3	2	9,00	20,47	56,20	14,33	34,71	70,53	17,358	
4	3	8,82	21,4	55,35	13,95	35,35	69,78	17,145	
5	4	8,66	22,24	53,42	13,68	35,92	69,1	16,952	

Table 7. Technical analysis of light comositive briquettes paper / coal dust / limestone [17]

Ordinal	Molar ratio Ca/S	$W_{H(a)}$ (%)	$A_{(a)}$ (%)	Vol_a (%)	$C_{fix(a)}$ (%)	Coke residue (%)	Combustible (%)	$H_{g(a)}$ (MJ/kg)	$H_{d(a)}$ (MJ/kg)
1	0	9,38	18,48	57,28	14,88	33,36	72,16	17,817	
2	1	9,04	20,24	56,40	14,32	34,56	70,72	17,41	
3	2	8,74	21,85	55,61	13,80	35,65	69,41	17,04	
4	3	8,46	23,33	54,88	13,33	36,66	68,21	16,70	
5	4	8,19	24,72	54,20	12,89	37,61	67,09	16,38	

4. CONCLUSIONS

For light compositive biobriquettes from the aspect of technical analysis data it is possible to abstract following conclusions:

- low content of higroscope moisture about 5 % and total moisture too;
- low ash content, average 10 %;

- high content of combustible material part, over 80 %;
- high content of volatiles-combustible evaporable materials, average 73 %;
- coke residue average content is about 20 %;
- heat power is on the level of high quality lignite or brown-lignite coals, from 17,2 to 18,9 MJ/kg;
- volume heat power (reduced to bulk light compositive biobriquettes, from 4970 to 9000 MJ/m^3) which means that it is 2 to 10 times greater than for basic biomass.

Light compositive briquettes pulp/coal/limestone and pulp/coal/hydrated lime, according to results of technical analysis may be interest energy fuels (heat power has average about 17 MJ/kg, volume about 8000 MJ/m^3). Incorporated sorbent into structure of briquette makes not only hypothesis for desulfurization of smoke gas [18, 19] but already looks like it very well tributary to briquette resistance [20].

All here specified point to the fact that light compositive biobriquettes possess whole line of racily advantageous properties for use. However, further researchings are necessary, esspecially combustion in real conditions. For this part of researchings in laboratory for combustion on Occupational Safety Faculty is made instalation on which will be observe this part of experiment. After researchings of economical indicators of light compositive biobriquettes usability authors expect larger application and production.

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UPOTREBNA VREDNOST LAKIH KOMPOZITNIH BIOBRIKETA

Dragan Mitić

U literaturi postoji određeni broj podataka o lakim briketima, ali se oni ne mogu smatrati dovoljnim za donošenje opštih zaključaka o mogućnosti njihove upotrebe. U ovom radu su prezentovani rezultati eksperimentalnih istraživanja na kompozitnim biobriketima koja su rađena u Laboratoriji za sagorevanje na Fakultetu ZNR u Nišu. Autori gaje nadu da će ova istraživanja pomoći da se temeljitije prouči mesto i značaj kompozitnih biobriketa sa ekonomskog, ekološkog i energetskog stanovišta.

Ključne reči: *laki kompozitni biobriket, mogućnost upotrebe, ekonomija, ekologija, energija*