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LIGHT COMPOSITIVE BIOBRIQUETTES - PHISICAL CHARACTERISTCS

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Abstract. *Compositive biobriquette offers remarkable possibilities for incorporating of: biomass (as basic material), coal dust as waste from separation and sulphur sorbent as an additive. This is the way for producing of fuel where we don't have to use paste or stuff, its heating value is extensively improved by different and various additives which most often may be treated as waste-secondary material. Additive material is attaching to improve mechanical, thermical or estetical properties of biobriquettes. In this paper are presented results of physical characteristics of these compositive light biobriquettes, produced in laboratory for combustion on Occupational Safety Faculty in Nis.*

1. INSTEAD OF INTRODUCTION

Concept of heavy and light biobriquette, production technology bases

Biobriquette allude product of briquetting technology operation-compact form of biomass which possess much greater volume mass, comparing to volume mass of biomass material from which biobriquette is made of [1].

Briquetting technology operation involves high pressure effect on grinded biomass, together with biomass material moving through the tool whereupon material temperature is rising. By this way activated physico-chemical processes lead to thermoplastic deformations of lignocellulose material and granulated material particles strapping into compact complex - biobriquette [1,2].

This way produced biobriquette belongs to the group of so called heavy briquettes (their volume mass is most often over 1100 kg/m^3). In contrast to them, it is possible to produce light biobriquettes with volume mass from 400 to 650 kg/m^3[3].

Light briquette forming technology essentially differs from tehnologije heavy

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briquette forming technology. As a basic forming briquette material here is used old paper (and industrialy recycled, too) in the form of lignocellulose pulp in water suspension, with or without additions of another biomasses. Toward to increasing of briquette heat power, usefullness or other properties it's possible to put in water suspension other biomasses too (cortex, sawdust, needles, branchery, huskus and cuttings of grape-vine...), coal dust or other additives. Important detail is possibility to incorporate dregs of stone fruits (great amounts from fruit industry) into light compositive briquette mass. It's possible to use stones of sour cherry, sweet cherry, peach, appricot, and stone shells of wal-nut, almond, hazel-nut...In this case from these mixtures it's possible to produce light compositive biobriquettes by pressing of suspension in appropriate tool with pressures which are not higher than 0,3 – 0,5 MPa [1,3]. Pressing is displacing the greatest amount of water and the rest is removing by dryingon the air. Drying time depends of the shape and i size of briquette, its structure, components and drying conditions, but aproximately (author's experience for briquette size ∅ 82,5×200 mm) doesn't last more than 10 days. [2]. Briquette compactivity is achieved thanks to space net of cellulose fibres which ties adherent mass- sawdust or grinded cortex [3].

Advantages and disadvantages of light compositive biobriquette

Light compositive biobriquette presents alternative solution to heavy briquette or heavy briquette produced by high pressures with minimal grinding [1]. In contrast to heavy briquettes, light compositive biobriquette possess:

a) advantages:
- cheap technical solution of the briquetting device;
- it's possible briquetting of material which makes compositive heterogenic structure with particles greater than 10 mm (depending of the briquette size);
- it is not necessary previosly biomass drying to some requisite moisture;
- requisite pressure is quite lower regard to pressure requisite for heavy biobriquettes forming;
- it's possible to incorporate sulphur sorbent;
- it's possible to store them without problems which follow storiging of heavy biobriquettes (voluminivity, swollening owing to humidity and eventual disintegration) [2];

b) and disadvantages:
- producing process is connected with preparation of pulp on the basis of paper and water, which demands a certain time period for paper disintegration and homogenization of the composite,
- after wet briquette forming a certain time period is needed for drying, which is relatively long for air drying. Drying time depends on briquette dimensions and by author's experience, for briquette ∅ 82×(250-300) mm, is max. 10 days.
- if there is artificial drying, it is additional expense [1].

2. MATERIAL AND METHOD

As material for preliminary researchings here is used lignocellulose pulp from old

roto-paper and like adherents i additives: coal dust of brown-lignite coal "Soko" granulation 0–2 mm, calcium carbonate from the industry of lime and nonmetals "Ostrovica", sacked hydrated lime of trade origin for commercial purposes and biomass [1]. As biomass component were used:

- beech sawdust (granulation 0–2 mm);
- ash chippings (≠1×20×30 mm);
- nut shell (≠2×20×30 mm);
- rice shell (natural size, nongrinded);
- huskus of grape-vine (granulation 0–10 mm);
- cuttings of grape-vine (∅ 5–10×10–20 mm)

In producing of compositive biobriquette on basis of lignocellulose pulp, coal dust, calcium-carbonate and hydrated lime are established molar ratios calcium to sulfur, Ca/S which are: 1; 2; 3; 4; and compositive briquette paper-coal-dust, without third component. Compositive briquette components in the form of calcium-carbonate and hydrated lime has a role of sulfur sorbent in combustion process [4,5,6].

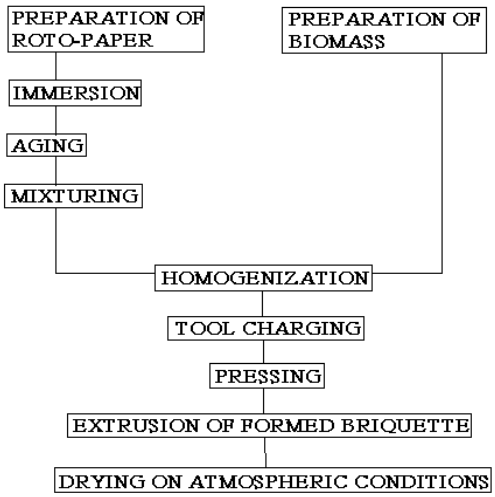

Fig. 1. Technological operations in forming process of light compositive biobriquette (applied in laboratory za for combustion on Occupational Safety Faculty in Niš)

Here is used brown-lignite coal "Soko" from the mine Čitluk, piece volume mass 1413 kg/m^3 and bulk volume mass 890 kg/m^3 [11]. Screen analysis is described detaily in [13]. Granulation is in the range 0–2 mm with the maximum residue on screen with aperature of 1 mm, about 39 %. Range of used calcium-carbonate is 0–2,5 mm, with the maximum residue on screen with aperature of (0,71–1) mm, about 50 %.

Technic-technological possibility of briquetting are tested on laboratory press of self-construction [1]. Press is made of steel welded construction with 2 steel columns diameter ∅ 30 mm which serve at the same time as bearer of upper part of tool and like guideline of movable base on which is under tool part for briquetting. Necessary force for pressing

is achieving by hidraulics with manual drive, and measuring of manual force is doing on the tang of manual hidraulic mechanizm. Tools for briquette producing allow production of cylindrical compositive light biobriquettes ∅ 35 mm and ∅ 82,5 mm. Dimensions ∅ 35 mm and ∅ 2,5 mm are assigned only for briquette production from cellulose pulp i.e. waste paper and compositive briquettes in which like crewel medium serves cellulose pulp. Tools are made of steel material with close typ matrix. Press detailed description is in [1, 7]. Briquette producing, testings and measurements were done in laboratory for combustioon on Occupational Safety Faculty and laboratory of MIN Institute in Niš.

Fig. 2. Light briquette diameter ∅ 82,5 mm; 1) waste paper pulp (left), 2) paper pulp, coal and limestone (in the middle) and 3) paper pulp and beech sawdust(right); Foto: D. Mitić

3. RESULTS

One of the worst characteristic of biomass which represents serious limit for their more mass use is little volume mass i.e. storage density. Because of it colecting, transport and storiging are more expensive. For certain biomass from tiller production exist technicly completed mechanization and different types of preparation (e.g. for straw) [1] and their volume mass has more satisfactory values.

In table 1. is shown abstract from detail overview of briquette volume mass tested in laboratory za for combustion on Occupational Safety Faculty in Niš [1]. These characteristics refer only to those biomasses which are used in production of light compositive biobriquettes.

Data about volume masses of tested light compositive biobriquettes and about bulk volume masses, are shown in table 2. It is possible to notice that range values of volume masses of light compositive biobriquettes is from 310 to 500 kg/m^3 and bulk volume masses from 253 to 445 kg/m^3 (for defined briquette geometry). Light briquette made only from paper pulp has average volume mass 367 kg/m^3 and bulk volume mass 263 kg/m^3. Light briquette whose pulp is made with lime milk has volume mass 656 kg/m^3 and bulk volume mass 253 kg/m^3. Data specified for light briquette with lime milk in water suspension refer to briquette dimensions ∅ 36×(360−620) mm. In spite to that volume mass is defined for conditions in so called corridor schedule, suitable for packing and transport. Out of this range is only light briquette, to which is added hydrated

lime in water suspension and which volume mass is about 650 kg/m^3 (for briquette ∅ 36 mm). Also is noticed that volume mass upper limit of tested speciments is a bit greater than till now was stated in literature (Radovanović [3] specifies range from 240 to 500 kg/m^3). Diferences are result of diverse biomasses which are incorporate into compositives. In this case are used biomasses with a lot of greater volume masses, such as pits and cuttings, in contrast to announced results which refers to using of needles, coarses and sawdust.

Table 1. Volume mass tested in laboratory for combustion on Occupational Safety Faculty in Niš [1].

Biomass	Bulk volume mass (kg/m^3)	Moisture content (%)	Granulation (mm)	Stage in which measurement was done
Cuttings of grape-vine	65	6,759	∅ 5×10–20	rinfuz
Huskus of grape-vine	148	6,712	0–10	rinfuz
Beech sawdust	169	6,675	0–2	rinfuz after cut processing
Nut shell			≠2×20×30	rinfuz
Ash chippings	28,2	6,264	≠1×20×30	rinfuz from raw scrape processing

Table 2. Volume masses of biobriquettes tested in laboratory for combustion on Occupational Safety Faculty [8,12]*

Ordinal	Structure	Dimensions of specimens (mm)	Volume mass range (kg/m^3)	Average volume mass (kg/m^3)	Average bulk volume mass (kg/m^3)
1	Paper	∅ 82,5×95	325–420	367	263
2	Paper-lime milk	∅ 36×360–620		656	253
3	Paper-cuttings of grape vine	∅ 82,5×175	500	500	455
4	Paper-huskus of grape vine	∅ 82,5×140	470–540	505	367
5	Paper-rice shell	∅ 82,5×145	310–320	315	247
6	Papir-beech sawdust	∅ 82,5×160	360–390	375	303
7	Paper-nut shell	∅ 82,5×125	390–450	420	305
8	Paper-ash chippings	∅ 82,5×145	320–340	330	253

*These results refer only to mass parts: paper pulp 0,5 and biomass 0,5.

When the word is about light compositive biobriquettes made of paper pulp, coal dust and sulfur sorbent like calcium-carbonate or hydrated lime-common conclusion is that volume mass is greater than volume mass of compositive briquettes with biomass and ranges from 453 to 530 kg/m^3. Also bulk volume mass is greater too, from 312 to 435 kg/m^3. These results are logical respecting that volume mass of brown-lignite coal "Soko"is 1413 kg/m^3 and bulk volume mass is 890 kg/m^3 [11].

Review of volume mass and bulk volume mass light briquettes whose base is paper pulp, coal dust and sulfur sorbent is shown in tables 3. and 4. for a different molar ratios calciuma to sulfur (Ca/S).

Table 3. Volume masses of light compositive briquettes paper/coal dust/limestone, tested in laboratory for combustion on Occupational Safety Faculty [9]*

Ordinal	Molar ratio Ca/S	Dimensions of specimens [mm]	Volume mass range (kg/m^3)	Average volume mass (kg/m^3)	Average bulk volume mass (kg/m^3)
1	0	∅ 82,5×125	400–490	453	317
3	1	∅ 82,5×80	390–600	530	312
4	2	∅ 82,5×140	470–540	445	418
6	3	∅ 82,5×140	410–570	477	388
8	4	∅ 82,5×160	430–550	468	435

*These results refer only to mass parts: paper pulp 0,5 and biomass 0,5.

Table 4. Volume masses of light compositive briquettes paper/coal dust/hydrated lime, tested in laboratory for combustion on Occupational Safety Faculty [10]*

Ordinal	Molar ratio Ca/S	Dimensions of specimens [mm]	Volume mass range (kg/m^3)	Average volume mass (kg/m^3)	Average bulk volume mass (kg/m^3)
1	0	∅ 82,5 X 125	400–490	453	317
3	1	∅ 82,5 X 120	390–580	510	306
4	2	∅ 82,5 X 135	390–630	537	305
6	3	∅ 82,5 X 145	420–520	466	405
8	4	∅ 82,5 X 125	450–500	477	353

*These results refer only to mass parts: paper pulp 0,5 and biomass 0,5.

From comparison of volume masses of biomass in raw stage-rinfuz and volume masses of briquettes as well as bulk volume masses of briquettes is documented that there is great saving in storage space. If the saving of storage space is based on coefficient of usefullness of briquette storage space [1], we come to next data for light briquette in which is incorporated:

- cuttings of grape vine 85,72%
- huskus of grape vine 59,67%
- beech sawdust 44,23%
- ash chippings 88,86%

These results are based on bulk volume mass of biomass in raw stage-rinfuz. It can be noticed that there is very considerable saving of storage space nevertheless it’s a point on

light but not heavy biobriquette whose volume mass is from 4 to 5 times less than volume mass of heavy biobriquette.

Appearance of briquette voluminivity [1] which is expressive at heavy biobriquettes, is not noted at light biobriquettes at all. On the contrary, with longer staying light biobriquette is becoming more and more compact, so after drying it has mechanical characteristics which make it very appropriate for storage. Light biobriquette may be cut, it doesn't crumble and it's very appropriate for packing.

4. CONCLUSIONS

Volume masses of light compositive biobriquettes range from 310 to 500 kg/m^3. Volume masses of light compositive biobriquettes with coal dust and sulfur sorbent like calcium-carbonate range from 390 to 600 kg/m^3 and bulk volume masses from 312 to 435 kg/m^3.When the sorbent is dehydrated lime volume masses are from 445 to 537 kg/m^3 and bulk volume masses from 305 to 405 kg/m^3. Briquettes are compact, there is no crumbling, no cracking in drying phase, no voluminivity and it is possible to cut and engrave them. Saving of storage space (based on biomassin rinfuz) ranges from 44 to 88%. All specimens tested here, has mass part of pulp 0,5 and other adherents and additives together has mass part of 0,5.

According to these light compositive biobriquette offers outstanding possibilities in fuel production with three E characteristics:

- ecological;
- economical and
- energetical.

For ecological epithet is tied biomass use as renevable energy source, waste materials which very often represent ballast and load for environment (sawdusts, paper, coal dust, etc.). In presented researchings is tested possibility of incorporating sorbent into light biobriquette. Authors haven't done experimental part of researchings which refers to desulfurization of smoke gas, but with literature base [4,6] it is possible to expect desulfurization effects to 90 %.

It is economical because of the large spectrum of potential plant resources which are treated like secondary combustible materials, they are cheap and often accessible. Technic-technological process is cheap and easy feasible. Savings of storage space are significant, combustion is more qualitative and easy to organize, than with biomass in rinfuz state.

Characteristic of energy fuel is not worked out in this paper, but here is used information from [12], that light compositive biobriquettes may be a significant energy resource, on the basis of their heat power which ranges from 17 to 18 MJ/kg [12].

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LAKI KOMPOZITNI BIOBRIKETI - FIZIČKE KARAKTERISTIKE

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Kompozitni biobriket pruža izvanredne mogućnosti da se u njega inkorporiraju: biomasa (kao osnovni materijal), ugljena prašina kao otpad sa separacija i sorbent sumpora kao aditiv. Na taj način se dobija gorivo, za čiju se proizvodnju ne mora koristiti lepilo ili punilo, čija se toplotna moć znatno popravlja raznoraznim dodacima koji se najčešće mogu tretirati kao otpadni - sekundarni materijal. Aditivni materijal se dodaje u cilju poboljšanja mehaničkih, termičkih ili estetskih svojstava biobriketa. U ovom radu su prezentirani rezultati fizičkih karakteritika ovakvih kompozitnih lakih biobriketa, dobijenih u Laboratoriji za sagorevanje na Fakultetu ZNR u Nišu.

Ključne reči: *kompozitni laki biobriket, zaštita životne sredine, biomasa*