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Characteristics of Ashes from the Combustion of Cow Dung Biomass †

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Abstract: Cow dung biomass was collected from January 2019 to June 2019. The tests were carried out on the samples of ground biofuel with a fraction below 0.42 mm, subjected to incineration. The chemical composition of ashes and characteristic fusion temperatures were determined. Cow dung biomass ashes were found to contain chlorine, which can contribute to corrosive processes in boilers.

Keywords: solid fuels; cow dung; biomass; chemical composition of ashes; characteristic fusion temperatures

1. Introduction

Biomass is the most widespread and used renewable energy source characterized by the highest energy potential. It has the largest technical potential as a biofuel, which is estimated at 684.6 PJ a year, of which 407.5 PJ—is the contribution of solid biofuels. Their reserves include surplus biomass obtained in agriculture (195 PJ), forestry (101 PJ), fruit farming (57.6 PJ), and wood waste (53.9 PJ) [1].

Burning biomass causes the formation of solid by-products of combustion. It is estimated that around 480 million tons of ash from the combustion and co-firing of biomass can be generated worldwide every year, assuming that the amount of biomass burned is seven billion tons/year [2].

Their physicochemical properties have an impact on the use of waste from biomass combustion, which in turn depends primarily on the type of biomass and the combustion technology. All these factors mean that the waste generated after biomass combustion has very diverse and variable properties. A significant part of this waste is fly ash, whose variable chemical and phase compositions make it difficult to manage [3].

Experimental studies of the chemical composition of ashes and characteristic fusion temperatures of ashes from the combustion of cow dung biomass were determined. The tests were carried out in accordance with the Polish standard PN-EN 196-2 and PN-G-04535.

2. Materials and Methods

The cow dung solid biomass for own research was received from a private farm situated in the Podlasie Voivodeship. The analysis of biomass was carried out after drying the raw material in a laboratory dryer at 40 °C. After drying, the sample was equilibrated with ambient humidity and ground to analytical grain. To determine the chemical composition of the ash, the sample was burned at a temperature of 600 °C in a muffle furnace. Then the chemical composition was determined using a WDXRF Wavelength Dispersive X-Ray Fluorescence—Axios mAX—4.0 kW spectrometer from

Panalytical. Evaluation of the characteristic fusion temperatures of ashes under oxidizing atmosphere conditions was conducted by means of a high-temperature microscope.

3. Results and Conclusions

Waste obtained from the burning of biomass shows very diverse and variable properties. A significant part of this waste is fly ash, which has variable chemical compositions that make it difficult to manage [4].

Chemical composition of ashes from biomass combustion and co-combustion depends primarily on the type of biomass [5]. These ashes can contain basic ingredients in quantities up to several dozen percent [6]. The analyzed ashes showed various quantitative chemical compositions. Calcium composition predominated in the ashes from biomass combustion of cow dung (Table 1). They also contained a high content of silica, phosphorus, and potassium, which is characteristic of this type of waste [7]. The high content of sulfur and chlorine in the ashes tested can affect the corrosion of heating devices [8]. The chemical composition of cow dung biomass ash may change, depending on the animal species, their age, diet, and quality of feed, as well as the condition of the animal (poor or good condition).

Table 1. Parameters of the chemical composition of ashes from cow dung biomass.

Chemical Composition of Ash	Own Research January 2019	Own Research February 2019	Own Research March 2019	Own Research April 2019	Own Research May 2019	Own Research June 2019
Ashes (%)	12.49	8.90	9.25	10.53	8.75	13.90
Na (%)	2.57	3.05	1.02	0.96	3.10	1.50
Mg (%)	7.12	9.48	7.25	6.23	7.88	5.79
Al (%)	1.28	1.10	1.40	0.98	1.16	1.13
Si (%)	15.80	11.94	14.24	11.55	15.75	10.77
F (%)	16.92	19.20	18.82	19.04	16.43	17.74
S (%)	3.46	3.83	3.11	3.00	3.75	3.22
K (%)	7.47	7.99	9.22	6.30	6.37	3.59
Cl (%)	2.08	2.16	2.10	1.81	1.32	0.98
Ca (%)	41.01	32.62	28.69	32.88	29.06	39.33
Fe (%)	0.96	0.98	1.12	0.80	0.87	0.60
Rb (%)	0.04	0.06	0.00	0.04	0.04	0.04
Cu (%)	0.16	0.12	0.16	0.08	0.16	0.10
Zn (%)	0.53	0.48	0.52	0.34	0.53	0.24
Sr (%)	0.06	0.05	0.07	0.04	0.06	0.05
Mn (%)	0.57	0.72	0.72	0.55	0.57	0.37

The chemical and mineralogical composition of the ashes determines the values of the characteristic fusion temperatures. High-melting oxides and elements increase these values, while low-melting elements reduce them. The main high-melting components of fly ash are silicon and aluminum compounds, while the low-melting components include alkali compounds, among others, potassium, sodium, and organic compounds [9]. Ash from biomass is often liquid already at 800 °C and melts at much lower temperatures than coal ash, which may be one of the causes of sintering and agglomeration of ashes leading to defluidization of the fluidized bed [10]. The ash softening temperature of cow dung is in the range from 1240 to 1360 °C, while the melting point is from 1260 to 1470 °C (Table 2). The majority of cow dung biomass ashes tested showed high resistance to high temperatures.

In order to achieve a high energy effect, this solid biofuel should be dried, properly prepared, and combusted in adapted boilers, under continuous laboratory control of the chemical composition of the ash. Therefore, the basic parameters and physicochemical properties of cow dung biomass ashes were determined, which at the further stage of research will require the application of appropriate optimization procedures.

Table 2. Parameters of characteristic fusion temperatures of ashes from cow dung biomass.

Characteristic Fusion Temperatures	Own Research January 2019	Own Research February 2019	Own Research March 2019	Own Research April 2019	Own Research May 2019	Own Research June 2019
sintering temperature (°C)	1060	1190	1040	1150	1190	1040
softening temperature (°C)	1360	1310	1250	1270	1240	1350
melting temperature (°C)	1410	1330	1260	1320	1260	1470
flow temperature (°C)	1440	1340	1270	1370	1270	1500

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Conflicts of Interest: The authors declare no conflict of interest.1

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