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USING PAPER SLUDGE IN THE MANUFACTURE WOOD PELLETS

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Abstract

This work is focused on the processing of waste paper sludge and its energy utilization. The sludge is not suitable for the combustion due to low calorific value, which is adversely affected by the content of incombustible components. Paper and cellulosic paper sludge have a relatively low calorific value (5.7 to 7.8 MJ.kg^{-1}) after drying.

One of the possibilities to increase the calorific value of sludge is the production of wood pellets containing an amount of sludge. In this work is an experimental investigation of the pellets containing sludge and sawdust in order to verify an energy utilization of sludge. The experimental samples were produced in the following proportions: 50/50 (sawdust/ sludge), 40/60 and 30/70. The properties of samples were determined by thermogravimetric analyser and calorimeter. The results show that increasing content of the paper sludge in the produced pellets reduces the combustion heat and increases the ash content.

Key words: *waste sludge, paper, pellets, combustion heat, ash*

INTRODUCTION

Paper industry in Europe produces over 11 million tons of waste per year, and 70% comes from processing recycled paper. The high operation cost of landfill with the paper sludge requires finding a solution for its further use. The application itself is dependent on the use of physical-chemical properties of the sludge. In the energy sector, the paper sludge is also used for combustion. [3].

The current utilization of paper sludge is in the following processes: pyrolysis, gasification, composting, as an ingredient in construction materials or for building works (as powder). Among the cheapest and easiest way of paper sludge processing is incorporation directly into the soil and composting. It is also known for the manufacture of bricks, which is used either directly as an ingredient to a mixture of brick which enables the production of lighter bricks, saving time and energy for firing, or used as a filler for cavities, as for firing the sludge is burned, and the cavity remains empty [1].

Paper sludge is also used in the energy sector for thermal processes. Regards the combustion the energy is utilized for heating.

EXPERIMENTAL MEASUREMENTS

The company Metsä Tissue Slovakia provided paper sludge for this research. At present, the company is a global producer of wood products. Production is mainly focused on the

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production of paper products used every day in homes and wooden components used in industry and construction. Fig. 1. shows the amount of sludge produced by the company in recent years.

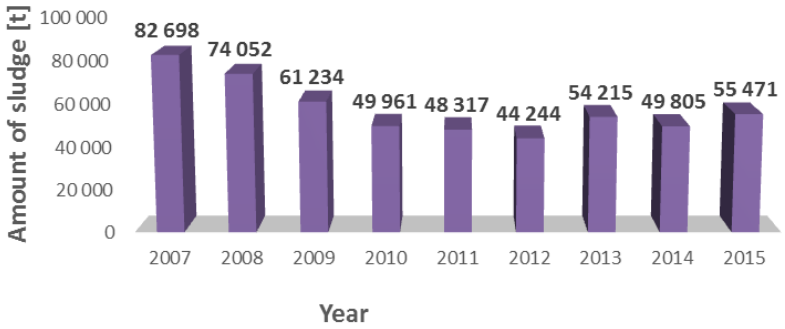

Fig. 1 The amount of sludge produced in Metsä Tissue Slovakia

For research has been used recycled paper with the content of cellulose. The investigated paper sludge can be seen in Fig. 2 and analysis of the chemical composition is in Tab. 1.

Tab. 1 The chemical composition of ash

Name	Concentration	Measurement accuracy
Dry matter 105°C	53,0%	5%
Ash content (Dry basis)	70,5%	5%
Total sulfur	0,04%	-
CO_3	37,7%	-
Na_2O	0,031%	10%
K_2O	0,053%	11%
CaO	54,99%	5%
MgO	1,02%	10%
Al_2O_3	3,292%	15%
SiO_2	4,488%	10%
Titanium dioxide	0,094%	15%
Fe_2O_3	0,205%	15%
MnO	0,012%	10%

Fig. 2 Wet paper sludge

Analysis of paper sludge

Experimental research included finding the essential features and characteristics of the sludge. In the first phase was measured the moisture of sludge. In total five measurements were performed and the average moisture content was w=51%.

Subsequently the higher calorific value was measured by the calorimeter LECO AC 500. Measurement of gross calorific value is based on the law of conservation of energy. The heat released by the investigated substance shall be equal to the heat that is absorbed by water and calorimeter. Five measurements were carried out and the average gross calorific value is 5.84 $MJ.kg^{-1}$.

The lower calorific value of sludge was calculated based on the gross calorific value obtained from the calorimeter and the measured humidity and the average value of LCV is 3.57 $MJ.kg^{-1}$. For further research was chosen production of pellets from paper sludge. Pellets were produced from sludge with the moisture content to about 51% (Fig. 3 left), and 12% (see Fig. 3 right) in the small pelletizer.

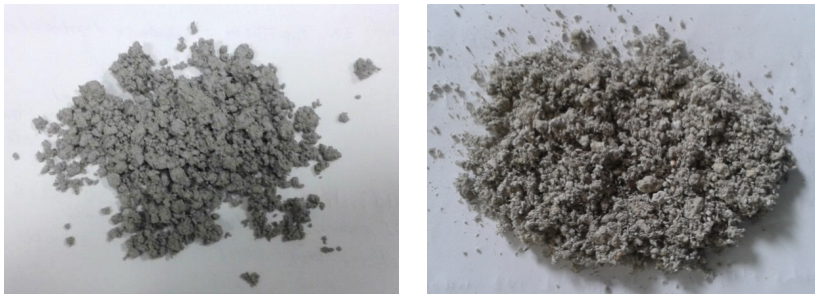

Fig. 3 Paper sludge with moisture content to about 51% (left) and 12% (right)

The pellets of the raw sludge were too soft and broke up easily. The structure of produced pellets can be seen in Fig. 4 (left - pellets: w = 51%, right - pellets: w = 12%).

Fig. 4 Pellets from paper sludge with moisture content to about 51% (left) and 12% (right)

As expected, the produced samples of the pellets did not showed a significant increase of LCV. Therefore, the samples of the pellets were produced from a mixture of sludge and saw dust. Saw dust have a higher LCV and therefore was expected the increase of calorific value in the samples produced from the mixture.
Experimentally it was found that moisture content of input material must be between 20 and 25% in order to produce a high quality samples and to ensure a problem-free compression of the pellets with the minimum LCV of about 12MJ.kg^{-1}.
Five test samples of pellets composed of a mixture of paper sludge and saw dust with different ratios were produced. Tab. 2 shows the characteristics of the produced samples.

Tab. 2 Characteristic of selected samples

Sample	Moisture %	Volatiles %	Ash %	Fixed Carbon %
50:50	5,405	47,190	22,23	5,165
60:40	5,225	65,120	26,83	2,815
70:30	4,690	63,690	30,89	0,730

The content of carbon, hydrogen and nitrogen was measured on LECO CHN 628. The device works on the principle of two-stage furnace where the temperature reaches 1050 °C. The analysis of the samples was carried out at a constant temperature of 949 °C. The combustion was carried out with pure oxygen to ensure complete combustion of all organic samples without the addition of the necessary additional oxidizing metal or other gases.
The sulphur content was measured on LECO 628 S, which provides independent determination of sulphur in small sample (350 mg). Sulfur analysis was detected by combustion at 1450 ° C with very short analysis times (less than 2 minutes). Tab. 3 shows the levels of sulfur, nitrogen, carbon and hydrogen.

Tab. 3 The content of sulfur, nitrogen, carbon and hydrogen in the samples (wet basis)

Sample	C %	H %	S %	N %
50:50	36,021	4,702	0,044	2,590
60:40	34,996	4,533	0,016	2,783
70:30	32,899	4,188	0,034	2,618

RESULTS AND DISCUSSION

For proper evaluation, the measured results were compared with the properties of wood pellets. From the comparison is obvious that wood pellets have the highest value of LCV and produced pellets reach lower LCV, which was expected.
Fig. 5 presents average concentration of carbon, hydrogen, and nitrogen. It can be seen that the highest concentrations of carbon and hydrogen are in the wood pellets on the other hand, the lowest concentrations were measured in the sample 70:30 (paper sludge:saw dust). It can also be noticed that the wood pellets have the lowest content of nitrogen.

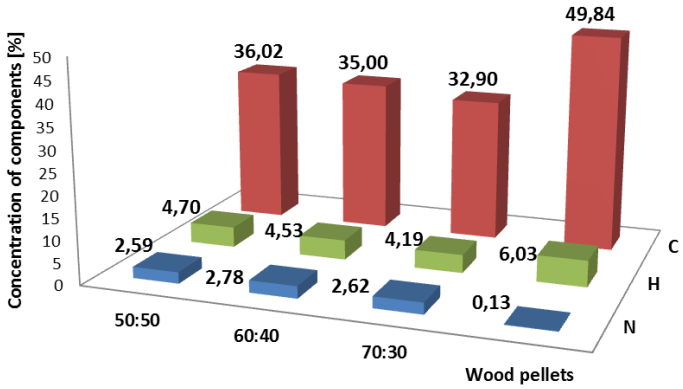

Fig. 5 Concentration of carbon (*C*), hydrogen (*H*) and nitrogen (*N*)

The ash content of the samples is shown in Fig. 6. The produced pellets have much higher ash content compare to wood pellets. The higher content of sludge in the samples causes higher ash content.

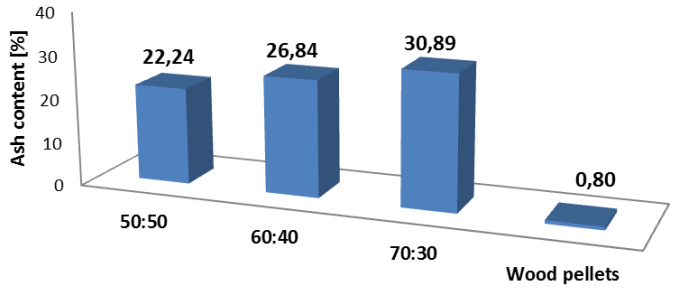

Fig. 6 Comparison of ash content

The high concentration of ash is caused by higher content of non-combustible particles in the sludge. This may cause clogging of the burner during combustion and flame suffocation due to deposition of ash in the vicinity of the burner.

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