Annals of Warsaw University of Life Sciences - SGGW
Forestry and Wood Technology № 87, 2014: 40-44
(Ann. WULS - SGGW, For. and Wood Technol. 87, 2014)

Combustion of fuel blends derived from lignocellulosic materials and peat in a small power combustion chamber

WOJCIECH J. CICHY

Wood Technology Institute, 60-654 Poznan, ul. Winiarska 1, Poland

Abstract: The paper presents the results of research on obtaining fuels derived from plant biomass that will be able to replace traditional fossil fuels. The aim of the study was to investigate the effect of co-firing different types of woody biomass with peat in a small power combustion chamber. Sawdust from conifers, wood chips from willow, postconsumer wood ("old furniture"), peat and fuels derived from woody materials mixed with peat in a 1:1 ratio were tested. It has been found that the combustion of fuel blends involving different types of woody biomass and peat resulted in a reduction of adverse effects observed during the combustion of pure peat (low amount of carbon-monoxide in the exhaust gases). In the case of solid biofuels from chemically treated biomass (old furniture), the share of peat in the fuel blends caused a decrease in the content of nitrogen oxides in the exhaust gases in comparison to fuels containing 100% "old furniture".

Keywords: biomass fuels, peat, fuel blends, combustion of biomass and peat, small power combustion chamber

INTRODUCTION

In 2008, the European Parliament adopted the so-called "Pack of 3 x 20", in which EU Member States are obliged to fulfil a number of tasks designed to counter global warming. These tasks are: to reduce by 2020 carbon dioxide emissions by 20 percent, reduce energy consumption by 20 percent, and increase energy consumption from renewable sources to 20 percent.

In the conditions of our country it has been decided that the combustion of biomass will constitute the primary source of renewable energy sources. It seems that the biggest sources of biomass potential for use as energy carriers in Poland are: woody biomass and herbaceous biomass (wastes from agricultural crop production). Another aspect of the use of this material is the fact that the combustion of solid biofuels (for economic reasons) allows us to quickly fill Poland's international obligations in the field of electricity and heat production from renewable sources. Therefore, measures aimed at the acquisition of new, renewable raw materials that can be processed into biofuels comply with the provisions of the Polish Energy Policy until 2030, adopted by the Council of Ministers in 2009.

At the moment in Poland there is a significant deficit of wood that can be used to generate power. This is due to the limited forest resources in Poland, which cannot meet the demands of an extensive wood processing industry. On the other hand, the program of development of energy based on renewable energy sources focuses primarily on the use of various types of biomass. So far, the basic types of biomass used in large power plants in Poland are all kinds of waste from the woodworking industry and postconsumer wood waste. A characteristic of these type of fuels is their high chemical purity and low calorific value.

In some countries, a traditional fossil fuel besides coal is peat. This material was recently used for the energy generation in some parts of our country. In some situations it is possible to use this specific material for energy production. The available literature does not encounter information about the behaviour of this material during co-fired with biomass.

The aim of the study was to investigate the effect of the co-firing process of peat and different types of biomass in energy low-power devices.

MATERIALS AND METHODS

Typical woody materials in character of biofuels were used for testing. For this sawdust, willow chips and postconsumer wood waste ("old furniture") were studied. The second type of fuel was peat from agriculture activity. Blends of peat and sawdust, peat and willow chips as well as peat and postconsumer wood waste ("old furniture") in a 1 : 1 proportion were prepared.

Studies on selected samples of fuels and their blends were carried out in a laboratory with the following equipment:

- Furnace for burning solid fuel (especially for solid biofuels) with the 25 kW power boiler,
- Chimney for exhaust gases,
- Heat storage tank with a capacity of 3000 dm^3 with a hot and cold water circulation installation,
- Heat exchanger,
- Parameter control system.

Combustion tests were carried out on the basis of own procedures developed with previous experience derived from other research projects.

The analysis of the exhaust gases was carried out with the exhaust gas analyzer LANCOM Series II made by LAND COMBUSTION company. The instrument enables the measurement of the content of exhaust gases such as oxygen, carbon monoxide and dioxide, nitrogen monoxide and dioxide, sulphur dioxide.

During the measurement process other parameters of the combustion process were also observed:

- exhaust gas temperature,
- the temperature inside the furnace chamber,
- circulating water temperature,
- the thermal efficiency of the installation,
- the efficiency of the combustion process.

The results of the emission of exhaust gases were converted according to the PN ISO 8756: 2000 standard and calculated to 6% of the oxygen content, following the procedure described in the standard mentioned above.

RESULTS

Biomass materials were characterized with moisture content of about 20%. A characteristic feature of peat was its relatively high moisture content (about 65%). This fact directly influenced the course of the combustion process observed as the emission of CO_2, CO and NO_x.

The results of measurements of carbon monoxide, carbon dioxides and nitrogen oxides for the analyzed measurement cycles, and the averages are summarized in Figures 1-3. The high moisture content of the burned peat (about 65%) in relation to the biomass fuel (19 ÷ 27%) affected the reduction of the efficiency of the combustion process shown in Fig. 1 causing about three-fold reduction in carbon dioxide emissions and five-to tenfold increase in carbon monoxide emissions (Fig. 2) with respect to the biomass fuel. The nitrogen content in peat at a level comparable with clean woody biomass caused that emissions of nitrogen oxides from burning peat were reported at a similar level as observed during combustion of clean woody biomass (Fig 3).

Blending peat with woody materials was expected to give fuels containing biomass with more favourable properties, stabilizing the combustion process of these fuels. The presented data show that these expectations are met. Evidenced by the significantly increased content of carbon dioxide in the exhaust gases produced during combustion of fuel blends

with peat and a reduction in carbon monoxide compared to pure peat. In the case of postconsumer wood coming from "old furniture" burned with peat, the reduction of NO_x in the exhaust gases by nearly 50% in respect to the output of biofuel has been shown.

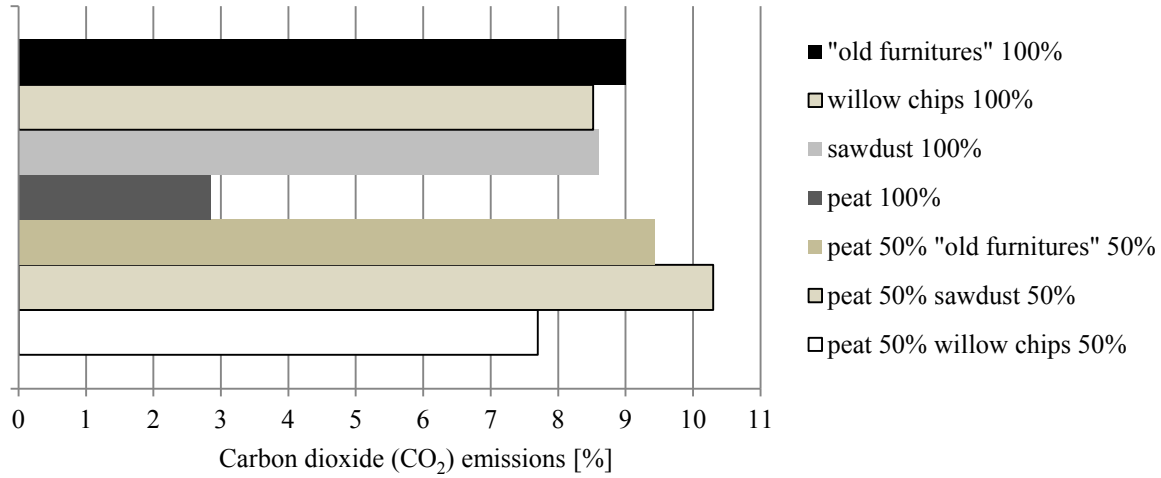

Figure 1. Carbon dioxide emissions during combustion of selected types of biomass, peat and their blends in a low power burner

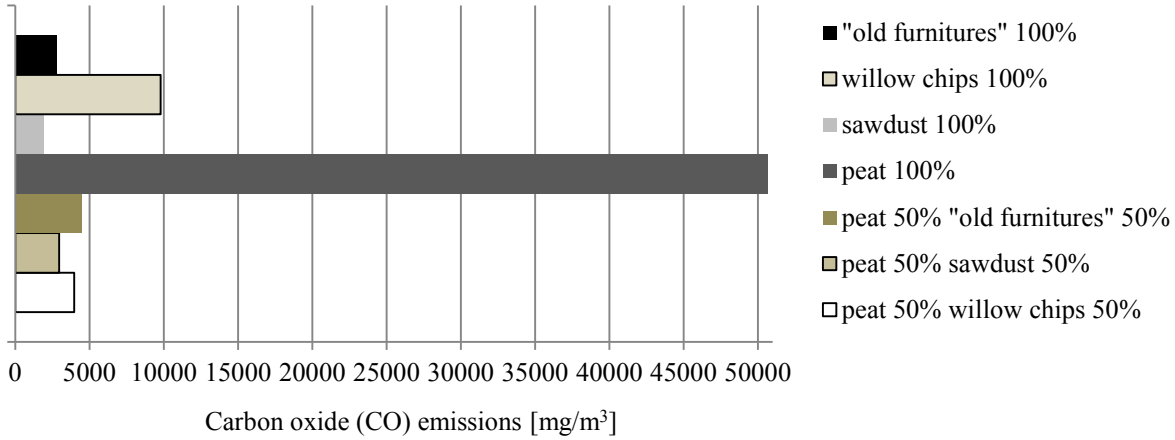

Figure 2. Carbon oxide emissions during combustion of selected types of biomass, peat and their blends in a low power burner

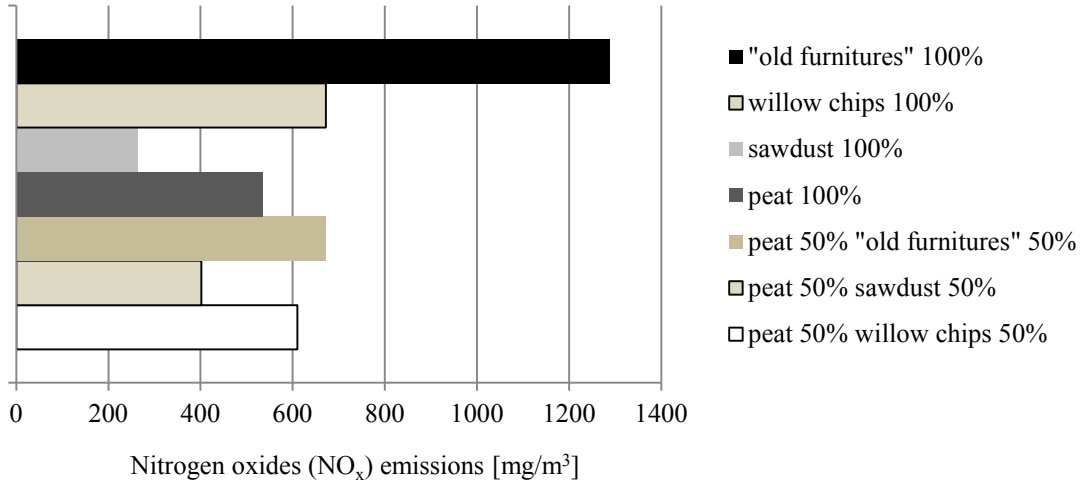

Figure 1. Carbon dioxides emissions during combustion of selected types of biomass, peat and their blends in a low power burner

CONCLUSIONS

During the research using small power combustion chamber, adverse impact of fuels derived from peat on the process of combustion concerning exhaust gases was observed showing a much higher content of carbon monoxide and low content of carbon dioxide. Mixing ratio of 1: 1 peat and solid biofuels derived from woody biomass significantly resolved these problems. In the case of burning of postconsumer wood, characterized by the high emissions of nitrogen oxides, the addition of peat significantly decreased NO_x content in the exhaust gases.

Generally, combustion of fuel blends derived from various types of woody biomass and peat resulted in the improvement of combustion parameters comparing to combustion parameters of pure peat. In the case of solid biofuels from chemically treated biomass ("old furniture"), the share of peat in the blends caused a decrease in the content of nitrogen oxides in the exhaust gases.

ACKNOWLEDGEMENT

This study was supported by grant No. N N309 160438 from The Polish Ministry of Science and Higher Education

REFERENCES

1. BROWN R.C., 2011, Thermochemical Processing of Biomass. John Wiley & Sons, Ltd, Publication, Chichester.
2. CHENG J., 2010, Biomass to Renewable Energy Processes. CRC Press, Taylor & Francis Group, Boca Raton – London – New York.
3. CICHY W., 2012, Combustion of plywood waste in a low-power boiler. Drewno.Pr.Nauk.Donies.Komuk. 55, (187), 21-36.
4. CICHY W., PAWŁOWSKI J., 2010, Współspalanie węgla kamiennego i odpadów drzewnych na urządzeniach energetycznych małej mocy. Drewno.Pr.Nauk.Donies.Komuk. 53, (183), 5-33.
5. DEMIRBAS A., 2004, Combustion characteristics of different biomass fuels. Progress in Energy & Combustion Science, 30, 219-230.
6. JUSZCZAK M., 2012, Pollutant concentrations from a 15 kW heating boiler supplied with sunflower husk pellets. Environmental Protection Engineering, (38), 1, 35-43.
7. KOŁODZIEJ B., MATYKA M. [Editors], 2012, Odnawialne źródła energii. Rolnicze surowce energetyczne. Powszechne Wydawnictwo Rolnicze i Leśne Sp. z o.o., Poznań.
8. MARUTZKY R., SEEGER K., 1999, Energie aus Holz und anderer Biomasse. DRW-Verlag Weinbrenner GmbH & Co., Leinfelden-Echterdingen.
9. NUSSBAUMER T., 1991, Anforderungen an umweltfreundliche holzfeuerungsanlagen. Holz als Roh- und Werkstoff 49: 445-450.
10. RYBAK W., 2006, Spalanie i współspalanie biopaliw stałych. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław.
11. SALZMANN R., NUSSBAUMER T., 2001, Fuel Staging for NO_x Reduction in Biomass Combustion: Experiments and Modeling. Energy & Fuels, 15, 575-582.
12. WOPIENKA E., KRISTOEFEL C., KALLIO M., ZENG T., 2012, IEE/09/758/SI2.558286 – MixBioPells. WP 3/0 3.3 Production and combustion tests of alternative and mixed biomass pellets. http://www.mixbiopells.eu (stan na dzień 28 sierpnia 2014 r.).
13. VAN LOO S. & KOPPEJAN J., 2010, The handbook of Biomass Combustion and Co-firing. Earthscan, London – Washington, DC.

Streszczenie: *Spalanie mieszanek paliwowych otrzymanych z materiałów lignocelulozowych i torfu w palenisku małej mocy.* W pracy przedstawiono wyniki poszukiwań paliw stałych wytwarzanych z udziałem biomasy roślinnej, które będą mogły zastąpić tradycyjne paliwa kopalne. Celem pracy było zbadanie wpływu różnych rodzajów biomasy drzewnej procesie współspalania z torfem na urządzeniach energetycznych małej mocy. Badaniom poddano trociny iglaste, zrębki wierzbowe, drewno poużytkowe („stare meble") torf oraz paliwa uzyskane ze zmieszania tych materiałów drzewnych z torfem w stosunku 1:1. Stwierdzono, że spalanie mieszanek paliwowych z udziałem różnych rodzajów biomasy drzewnej i torfu powodowało zmniejszenie niepożądanych efektów zaobserwowanych podczas spalania czystego torfu (niska zawartość dwutlenku węgla i wysoka tlenku węgla w gazach spalinowych). W przypadku spalania mieszanek z udziałem biomasy drzewnej przetwarzanej chemicznie („stare meble") zawartość torfu w mieszance spowodowała zmniejszenie zawartości tlenków azotu w gazach spalinowych w odniesieniu do paliwa zawierającego 100% „starych mebli".

Corresponding author:

Wojciech J. Cichy
Wood Technology Institute
Winiarska 1, 60-654 Poznań, Poland
e-mail: w_cichy@itd.poznan.pl