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Energy utilization of waste materials from agriculture for domestic conditions

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Abstract

Using renewable energy sources has a great potential for industry and households now and also in the future. Biomass plays an important role in reducing fossil fuel consumption. However, biomass is divided into phytomass, dendromass and zoomass, it offers us the possibility of using agricultural waste – phytomass. Phytomass is compared with biomass economically available, but combustion properties of phytomass are worse. In our work we decided use different ratios of phytomass and dendromass for better combustion process. Dendromass without addition of phytomass was combusted for comparison. Phytomass with dendromass were burned in domestic boiler with fuel container, which allows make mixtures of two different biofuels in various ratios. There were monitored thermal power, production of gaseous emissions, particulate matters production and flue gas temperature, which ensured optimal combustion process. Used boiler contained fuel container, so it was a continuous combustion of biofuel. Measurements showed that the use of mixtures of phytomass and dendromass is important mainly because the addition of dendromass can increase thermal power of boiler and reduce emissions production in comparison with separate phytomass combustion.

Keywords: biomass, combustion, domestic boiler

Streszczenie

Wykorzystanie źródeł energii odnawialnej stanowi wielki potencjał dla przemysłu i gospodarstw domowych - obecnie, a także w przyszłości. Biomasa odgrywa ważną rolę w redukcji konsumpcji kopalnych paliw. Jakkolwiek, biomasa dzieli się na biomasę roślinną (fitomasę), biomasę drzewną (dendromasę) oraz biomasę zwierzęcą (zoomasę), to daje nam możliwość wykorzystania zanieczyszczeń rolniczych – tj. fitomasy. Fitomasa jest w porównaniu do biomasy drzewnej bardziej dostępna ekonomicznie, ale właściwości spalania fitomasy są gorsze. W naszej pracy zdecydowaliśmy się użyć fitomasy i biomasy drzewnej w różnych stosunkach w celu uzyskania lepszego procesu spalania. Dla porównania była spalana biomasa drzewna bez dodatku fitomasy. Fitomasa z dendromasą była natomiast spalana w specjalnych domowych kotłach z zasobnikiem paliwa, który umożliwia zrobienie mieszaniny dwóch różnych biopaliw w różnych stosunkach. Monitorowano moc cieplną kotła, produkcję emisji gazów, produkcję pyłu zawieszonego i temperaturę spalin, które zapewniały optymalny proces spalania. Wykorzystywano kocioł, który zawierał zbiornik paliwa, więc było to ciągłe spalanie biopaliwa. Pomiary pokazały, że użycie mieszaniny fito-i dendromasy jest istotne, przede wszystkim dlatego, że dodatek biomasy drzewnej może zwiększyć moc cieplną kotła i zredukować produkcję emisje w porównaniu z oddzielnym spalaniem fitomasy.

Słowa kluczowe: biomasa, spalanie, bojler

1. Introduction

Biomass is nowadays becoming more and more popular source of energy. It is caused by declining supplies of fossil fuels and rising prices[1]. The great advantage of using biofuels is the recoverability, especially when using the planned cultivation off growing plants and low production of carbon dioxide (CO_2) for combustion, as the amount of CO_2 released only by the plant during growth adopted. At present the chemical energy from biofuels released mainly from combustion [2]. Biofuels represent about 15% of total world energy consumption, especially in the Third World, where they serve mainly for cooking and heating, but have a relatively high proportion of biofuels as well as in Sweden and Finland (17% and 19%), or in other developed countries [3].

The use of biomass for energy uses is becoming more active and supported by virtually the whole world. Until now, the most important source of biomass as fuel is wood in various forms [4]. It is due to the historical use of wood for heating of dwellings on our territory. Currently there is a trend to use all parts of the trees and plants, so use the waste components of wood, as are the branches and twigs, which crushes on wood chips [5, 6]. This can be directly burnt in the boiler rooms of various sizes with automatic or automated operation. It also uses the waste from wood processing in wood processing industry, in particular wood sawdust. They are extracted and manufactured from wood pellets, biofuels, or noble wood briquettes. This form of biofuel energy, ecological and environmental criteria, in addition to meeting the criteria of comfort and safety of the combustion [7]. The great advantage of wood pellets is their ability to use in automatic sources of heat in homes, where they can replace the automatic boiler burning natural gas [3]. Currently is a disadvantage of using wood pellets to their relatively high price, which moves above 200 €.t-1. With the rising cost of wood fuel was logical to seek other sources of fuel. We can say that there was a depletion of the availability of cheaper sources of timber and so began to use other sources such as straw, hay, various power plants and other fuels of vegetable or animal origin also. Agricultural biomass, plant biomass, more specifically, we can for the purpose of obtaining thermal energy incineration time into the rollers - pellets. With the burning pellets of phytomass related problems ash sintering, since fuel phytomass is generally low temperature ash melting behavior. Many scientific papers and studies dealing with chemical treatment of fuel in order to increase these values and by adding additives. Another way to prevent problems with the low temperature, the melting behaviour of plant phytomass with another fuel, for example, is a plant of various types of phytomass, or phytomass and fossil fuel plant. This work focuses as two types of co-incineration of biomass and on the mechanical treatment of the existing combustion device space to maintain the temperature within the chamber below the ash melting behavior of biomass used, which is also one of the possible solutions. Mechanical treatment of experimental combustion space of the boiler for combustion of pellets involves the use of a modulating burner and cooling water.

Table 1.1. Ash content and the melting point of ash is selected species biomass in the dry state

Fuel	Ash content A $(kg \cdot kg^{-1})$	The melting temperature of ash T (°C)
Spruce wood with bark	0.6	1426
Sallow – short shoots	2.0	1283
The bark of coniferous wood	3.8	1440
Wheat straw	5.7	998
Barley straw	4.8	980
Rape straw	6.2	1273
Grain of wheat	2.7	687
Silvergrass	3.9	973

A similar trend in search of cheaper alternatives wood fuel hit the owners of boilers burning wood pellets. Many owners of heat generators for burning wood pellets burn tested various alternative biofuels, including pellets made from various plants and waste substances, various plant seeds (corn cereals, sunflower, corn) and the like. The owners of these heat sources, however, sometimes do not realize that the boilers are designed to burn wood pellets, and so during the use of alternative bio-fuels leads to more problems. They are most commonly caused by high ash content of the fuel and low-temperature melting behaviour of ash. A typical problem is the combustion of such fuels spekancov creating clusters and ash in the combustion chamber, due to the low temperature melting behavior of certain phytomass ash (e.g. wheat straw). These clusters spekance and ash can reduce the effectiveness of the heat source, as are deposited on the heat exchanger, can create local overheating of the material, promote corrosion and contribute to other problems.

This article deals with one of the methods as to reduce problems during combustion of low grade cheaper biofuels based on phytomass, which are an alternative to woodfuels biofuels. The article describes the impact of co-lower quality pellets made of hay with less quality wood pellets in the combustion process in current heat source for combustion of wood pellets.

1.1. Phytomass

Biomass can be divided based on several considerations. According to the source of origin distinguish forest biomass (firewood, stumps, roots, etc.), agricultural biomass (phytomass, which is eg. Cereal straw, corn, hemp and Zoomass) and by-products from agriculture and manufacturing industries. By origin it can be divided into plant biomass, animal biomass - Zoomass and municipal and industrial wastes of biological origin [8]. As disposable source of biomass from agricultural primary production is calculated Slamni biomass cereals, maize, rapeseed, sunflower and waste wood from orchards and vineyards. It is a dry mass which can be used to produce heat by combustion. Table 1.2 are presented the biomass production of wheat and barley, expressed less the required number of straw bedding material and for feeding livestock. Straw moisture is actually in the range of 10-20%. Those are the calorific value of the dry sample, ie. are converted to 14% moisture. Energy potential was determined based on the calorific value of the biomass of each species [9].

Table. 1.2. The energy potential of the straw biomass

Crop	Biomass production (t)	Heat value $(MJ \cdot kg^{-1})$	Energy potential (PJ)
wheat	392 802	14	5.49
barley	171 278	14	2.39
corn	928 070	14	12.99
rapeseed	585 978	14	8.2
sunflower	232 920	14	3.26
Together	2 373 000		32.59

2. Experimental measurement

The essence of the experiment was to determine the feasibility of using co-lower quality pellets made of hay with less quality wood pellets to ensure a smooth combustion process in automatic heat source only intended for burning wood pellets because pellets from burning themselves on the hay has been tested heat source possible. During the experiments was determined heat output of the heat source and production of gaseous emissions, particularly carbon monoxide (CO), nitrogen oxides (NOx), organic hydrocarbons (OGC) and sulfur dioxide (SO2).

During the experiments were in the following different ratios coincinerated pellets made from biomass (Fig. 2.1)

•Alternative pellets - pellets of hay, grass pellets concrete mixes. Spotted relative humidity pellets was 7.5% (according to EN 14774-1 [10]). Spotted calorific value pellets was 16.5 MJ.kg-1 (according to EN 14918 [11]) and the observed ash content was 6.7% (according to EN 14775 [12]). Temperature melting behavior of ash - temperature deformation of pellets was 760 °C. The anhydrous sample contained 45.53% carbon, 5.72% hydrogen and 0.43% nitrogen.

•Wood pellets - lower quality pellets made from different kinds of woody biomass with a predominance of spruce wood containing bark. Spotted relative humidity pellets was 7.5% (according to EN 14774-1 [10]). Spotted calorific value pellets was 17.7 MJ.kg-1 (according to EN 14918 [11]) and the observed ash content was 0.8% (according to EN 14775 [12]). Temperature melting behavior of ash - temperature deformation of pellets was 1090 ° C. The anhydrous sample contained 49.84% carbon, 6.03% hydrogen and 0.13% nitrogen.

Fig. 2.1. Pellets of hay (left), wood pellets with bark (right)

Co-firing of alternative pellets, grass pellets of concrete mixes with less quality wood pellets were carried out in an experimental facility for testing heat sources, which was compiled from experimental heat source, equipment consumption, respectively. regulation of the heat produced by hot-water heat, gaseous emissions analyzer, measuring exchanges, to which are connected all measuring devices and record the individual variables that every 20 seconds a personal computer for the evaluation of the measured data. As the heat source was used automatic hot water boilers designed to burn wood pellets with a nominal heat output of 18 kW with a retort burner. All samples pellets in varying proportions of alternative content and wood pellets are burned in the same operating settings of the heat source - the time of administration of fuel was 18 s, off time was 25 the fuel combustion air was set at 40%.

3. Impact of co-combustion alternative pellets with wood pellets in the combustion process

During the experiments confirmed the assumptions that the combustion of alternative pellets themselves the source of heat that burning wood pellets will be complicated. The problem was the emergence slags and ash deposits, which was caused by low temperature ash melting behavior of alternative pellets, namely the low value of the softening temperature of ash. This caused clogging of the burner with the lower fuel supply (Fig. 3.2). To avoid clogging of the burner, it was necessary slags ash deposits at regular intervals (about 10 minutes) to remove not to extinguish the flame if possible other problems. Experiments were conducted co-combustion, so that the first actual incinerated wood pellets. The combustion of wood pellets themselves were expected trouble. Subsequently, the mixture gradually incinerated and alternative wood pellets in a ratio of 20% / 80% (A20 / D80) to 80% / 20% (A80 / D20) which has already been slags formation so great that combustion was not continuous and the resulting sintered deposits ash was necessary to manually remove.

Fig. 3.2. View into the combustion chamber of the heat source during the combustion of alternative pellets

Fig. 3.3 shows the experimental average heat output of the heat source during the co-combustion of alternative and wood pellets in various proportions. With a growing share of alternative pellets heat output of the heat source test declined, due to lower calorific value of alternative pellets compared to wood pellets and the influence of ash sintering, where there was a fuel removal no fire-through together with remainder in the ash of the boiler.

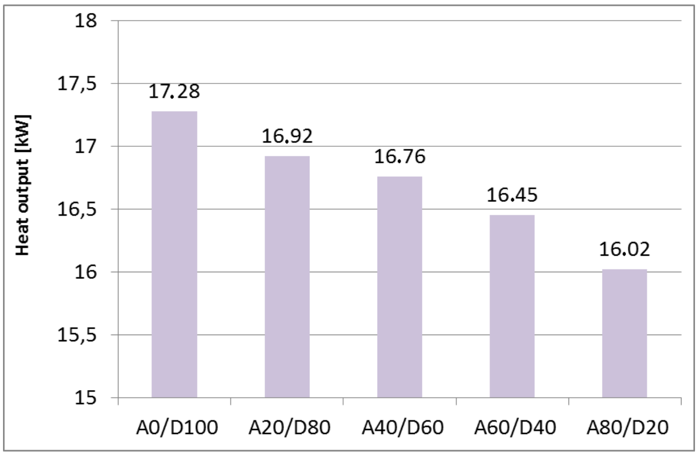

Fig. 3.3. The average thermal performance of the experimental heats our ceduring co-combustion of alternative and wood pellets in varying proportions

Fig. 3.4 shows the average production of CO and NOx during co-alternative and wood pellets in various proportions. With increasing ratio of alternative pellets increased CO production, due to impaired oxygen flame core considering slags formed, thereby increasing the ratio of combustion of alternative pellets became less perfect. Significant impact on the production of CO should also burning out combustible ash in the boiler. The production of NOx increases with increasing ratio alternative to pellets Wood pellets, due to the higher content of nitrogen contained in the hay.

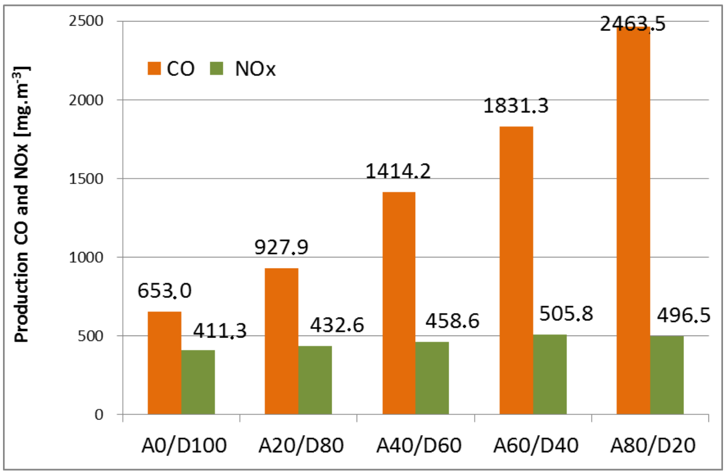

Fig. 3.4. The average production of CO and NOx during co-combustion of alternative and wood pellets in varying proportions

Fig. 3.5 shows the average production of SO_2 and OGC during co- combustion alternative and wood pellets in various proportions. Production of SO_2 increased with increasing the ratio of alternative pellets, due to higher sulfur content in hay compared to wood pellets. OGC production increases with increasing ratio of alternative pellets in which the ratio of 80% of the pellets alternative to wood pellets was triple the production during the combustion of wood pellets themselves.

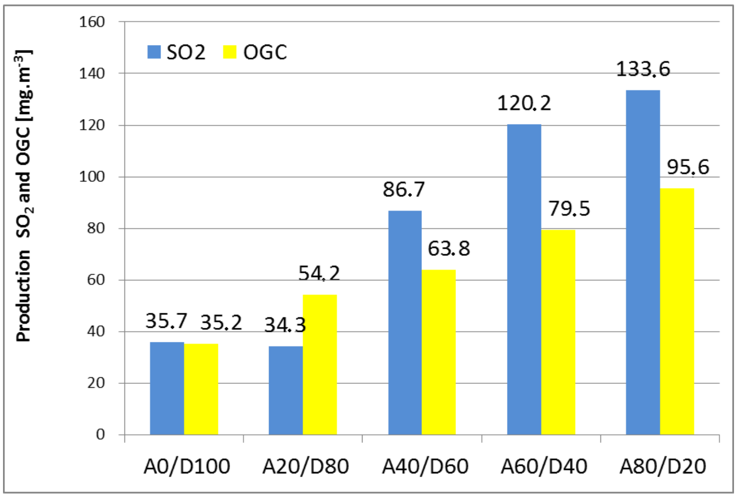

Fig. 3.5. The average production of SO_2 and OGC during co-combustion of alternative and wood pellets in varying proportions

4. Conclusions

Co-combustion of alternative pellets from hay with less quality wood pellets in the heat source with a retort burner designed for burning wood pellets routine is not ideal and requires frequent operator intervention - in particular removing slags and ash deposits on the burner, and much more frequent removal of ash from the ash of the boiler. An increasing proportion of alternative pellets negatively influenced the heat output of the heat source and negative also had an impact on the production of all monitored gaseous emissions. Based on the information obtained during the experiments, we can conclude that incineration alternative pellets wood pellets in the heat source for incineration conventional pellets with a retort burner sufficiently reduces problems burning biofuels based on phytomass, having a low ash melting behavior. In order to be co problematic biofuels with other fuels successfully operated in conventional heat sources, it may be necessary to test fuel with different properties, in particular with a higher ash content, where there has been some mixing ash with low and high temperature melting behavior. Another alternative to achieve satisfactory combustion of biofuels problematic in traditional heat sources may use additives, or modify the design of the combustion chamber.

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